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1956

Contributions of Research to Telephony—a Look at the Past and a Glance into the Future

MERVIN J. KELLY

The Strategic Air Command

MAJOR GENERAL R. M. MONTGOMERY

Air Ion Generation, Separation, Metering and Physiological Effects

W. WESLEY HICKS

Nuclear Resonance Fluorescence in Some Heavy Nuclei

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Franklin Institute:
Research Notes
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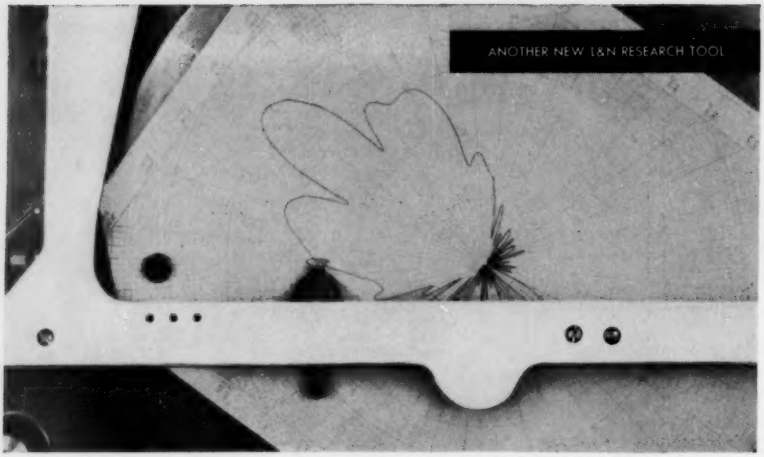
VOL. 261 NO. 2



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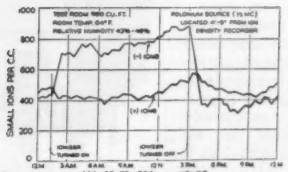

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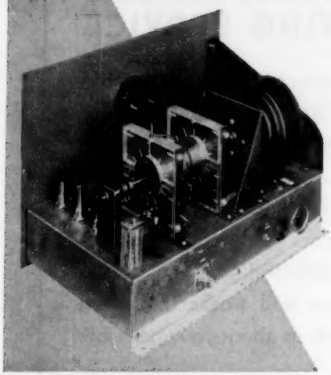

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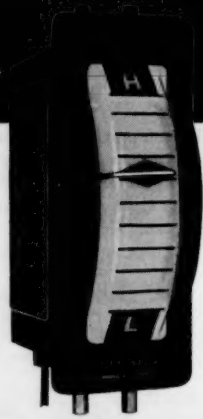

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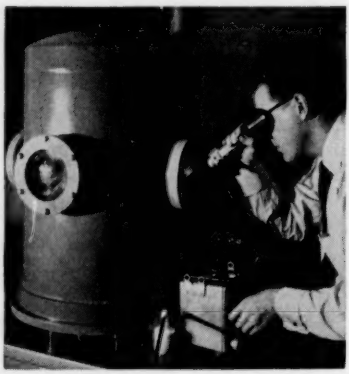

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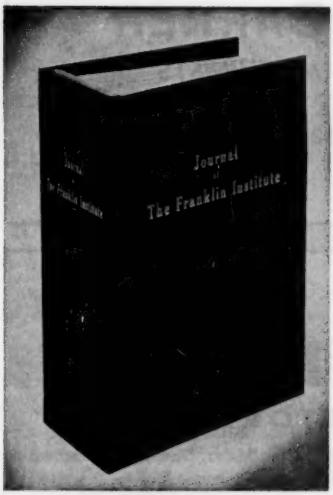

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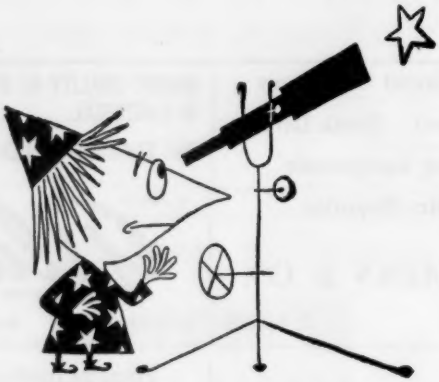

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Vol. 261 FEBRUARY, 1956 No. 2

CONTRIBUTIONS OF RESEARCH TO TELEPHONY—A LOOK AT THE PAST AND A GLANCE INTO THE FUTURE *

BY

MERVIN J. KELLY [1]

It is a singular honor and privilege to be with you tonight to present the first Philip C. Staples Memorial Lecture. As some of you will recall, Mr. Staples' memory was honored, and his life and work beautifully described, in an address delivered by Mr. Wilfred T. Gillen to a joint meeting of The Franklin Institute and the Newcomen Society some two years ago. It would be both redundant and futile for me to attempt to match Mr. Gillen's charming rendition of the Staples story. Let me, therefore, simply remind you that Mr. Staples' 67-year span from 1882 to 1949 included 43 years of association with the Bell System, culminating in 14 years as President of the Bell Telephone Company of Pennsylvania and the Diamond State Telephone Company. Besides his full and distinguished career in the telephone business, Mr. Staples, in innumerable ways and with marked unselfishness in time given, brought benefit and pleasure to his fellow man. Such words as able, genial, graceful, human, and other eulogisms come tripping to the tongue of anyone who was privileged to associate with him as I was for many years. Of Philip Staples it may be said as it was of Sigurd, the dragon-slayer in Icelandic mythology: "He never left speaking before that to all men it seemed full sure that no otherwise must the matter be than as he said. Never did he lose heart and of naught was he adred."

In his lifetime, Philip Staples witnessed and helped to bring about

* This is the first of an endowed series of annual lectures known as the Philip C. Staples Memorial Lectures, honoring a former President of The Franklin Institute and of the Bell Telephone Company of Pennsylvania. The series was made possible through the generosity of four companies and 89 of Mr. Staples' friends. This first Philip C. Staples Memorial Lecture was delivered at the Stated Meeting of The Franklin Institute on November 16, 1955.

[1] President, Bell Telephone Laboratories, Inc., New York, N. Y.

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an enormous advance in telephony in the United States—an advance that, more often than not, surpassed the imaginations of those who participated. The complete explanation for this advance involves many factors. Demand was forthcoming due to economic forces of unprecedented power and social proclivities that brook no denial. Exceptional managerial enterprise, to which he made large contribution, was certainly an ingredient. To me, however, the contributions of scientific research and development seem to transcend all other factors.

Because such a topic seems especially appropriate to the memory of Philip Staples and for presentation before The Franklin Institute, I have chosen to tell you tonight of the contributions of research to telephony. First, I should like to review the past to see how research has furthered the progress of telephony. Then, taking as a basis the contributions recently made by research, together with those we may expect in a reasonable span of years, I shall offer a few predictions about the future of telephony.

In looking backward, a convenient period, and one which fairly well overlaps the career of Philip Staples, is the last three decades. This period has further significance since the Bell Telephone Laboratories, which is the research and development unit for the Bell System, came into existence just a little more than 30 years ago, on January 1, 1925.

While the integration in the Bell Laboratories of all the research, development and design activities of the Bell System was accomplished 30 years ago, actually such activities have existed in the System since its birth. The telephone was invented in the course of research studies on hearing. Progress in telephony since that time has been paced by our progress in converting new scientific knowledge into communications technology through research and development.

Thirty years ago there were 17,000,000 telephones in the United States. Today there are 56,000,000, three and one-third times as many. This means one telephone for every three persons in the country, a higher ratio than exists anywhere else in the world. The United States, with only 6 per cent of the world's population, possesses 55 per cent of the world's telephones.

The expansion of the long distance business has been even more spectacular. The network of long distance circuits has multiplied some fourteenfold, from 3,000,000 circuit miles to 42,000,000. The volume of daily toll messages has multiplied five times, from 1,300,000 to 6,500,000. Accompanying this increase in usage and providing some of the stimulation for it, has been a striking reduction in rates. Despite the effects of inflation, a Philadelphia–Chicago call, which 30 years ago cost $4.25, costs only $1.40 today, while the cost of a Philadelphia–San Francisco call has been brought down from $16.05 to $2.50.

On January 1, 1925 the only outside countries that could be reached from a United States telephone were Canada, Mexico and Cuba. Today a person in the United States can call more than 96 per cent of the telephones in the rest of the world. Overseas messages, nonexistent in 1925, now total well over a million a year.

All of this adds up to something worthy of attention. Even in a world grown somewhat blasé over the accomplishments of research, a world where change is the order of the day, the huge expansion in telephone usage stands out both in terms of its impact on society and the constant flow of new technology that has made such a growth possible. To appreciate the basis for the remarkable expansion of the telephone business, one must know something about the underlying technology. The complete picture is far too complex for us to trace this evening, but we can at least examine a few major items.

To my way of thinking, technical progress in the telephone era just behind us has been spearheaded by two devices—the electromagnetic relay and the vacuum tube. Of and around these two instrumentalities has been built today's telephone plant. Lest I be accused of oversimplification, let me hasten to add that countless other devices have played important, essential and often distinguished roles. But in the main, there were just two fundamentals—the relay for the complicated job of interconnecting telephone lines and the vacuum tube for extending transmission to ever greater distances. These were the foundation stones; today they are the symbols.

It is significant, I believe, that neither of these devices was new in 1925. The relay dates back to the early part of the 19th century and in much cruder form was the basis for the development of telegraphy which, in point of time, preceded telephony. For those of our audience who are unfamiliar with such things, let me explain that a relay is merely a device in which physical motion produced by electromagnetic forces closes or opens one or more contacts. In so doing it either establishes connections or stores up information, such as the number of the called party, until this information is needed.

The vacuum tube needs little explanation, since you make use of it every day in your radio and TV sets. In our business its primary service is as an amplifier to overcome the loss of energy that telephone currents undergo as they travel along a wire line. The idea of employing amplifiers to offset line loss is almost as old as the telephone itself. Lee deForest invented the three-element electron tube way back in 1907, but it was not until some five years later that our Laboratories created a high vacuum inside the tube that made available the first practical amplifying device.

Now let us see how the arts of switching and transmission have developed around these two devices. The combined and sequential efforts of fundamental and applied research, development and design carried out in our Laboratories have been basic to the development

of these arts. First, let me direct your attention to the switching function in a central office. The basic problem is to connect the calling telephone to the called telephone, either locally or through a circuit to a distant point. There are many auxiliary steps in the process, however, such as picking up the calling line, determining the desired number, selecting an appropriate path, determining whether the called station is busy, establishing the connection, ringing the bell, indicating when the conversation is over, and putting things back to rights so that other calls can be handled.

The first invention directed at automatic switching of calls at the central office was made only 13 years after Bell invented the telephone. But the development of reliable and economical means for this purpose proceeded slowly. In 1925 more than 90 per cent of the switching was still performed manually by operators. By that time, however, it began to be apparent that with the expected growth in number of telephones the demand for operators would, before many years, far outrun the available supply—this apart from difficulties of replacement and training due to the turnover in personnel. At the beginning of 1925 we had some 140,000 operators in the Bell System. If the percentage of automatic switching were the same now as then, well in excess of a half million operators would be needed, a number utterly unobtainable in our present social structure.

The situation has been saved by the rapid introduction of automatic switching, using relays and relay-like devices. This method is, after all, a form of that much-publicized thing known as automation. Instead of the 9 per cent of 1925, 86 per cent of the local switching is today performed automatically. This has enabled us to get along with only a 45 per cent increase in the 1925 number of operators instead of the fantastic increase that would otherwise have been needed. In addition, automatic operation has made it possible to provide economical and much faster telephone service in the face of soaring labor costs, now about two and one-half times the 1925 level.

The growth in telephone usage that the nation has experienced in these thirty years would certainly have been markedly less had not automation been progressively introduced. Even assuming the availability of the labor force, costs for service would have increased to such levels that the demand for service would have been much less than has been experienced.

Beyond the automation of the local plant, something new is now being added. The new thing is DDD—Direct Distance Dialing by subscribers without the help of operators. In addition to dialing local calls, many telephone customers can now dial calls to a great many areas throughout the country. The switching mechanism selects the route to the distant station. Should it find a particular route busy, it keeps hunting until it finds an alternate path that is not busy. Some years hence when this development is completed, substantially all

subscribers will dial their station-to-station calls wherever within this continent they may terminate.

With no operator present on a DDD call, complex mechanisms must be provided to record billing information automatically and later process it on a printed bill. The equipment for this purpose is known as AMA. These letters should not be confused with the American Medical Association. They stand merely for Automatic Message Accounting. The mechanism is composed almost wholly of relays and associated circuits.

Even more revolutionary than these advances in switching has been the progress in long distance transmission. The elements necessary for the revolution existed in 1925, but their influence had scarcely begun to be felt. The principal element was the high vacuum electron tube already mentioned. In fact, it was the application of the vacuum tube in the telephone business that ushered in the electronic age. By 1925 high vacuum electron tube repeaters were beginning to be used in some quantity on both open wire and cable circuits, and moderately satisfactory conversation was possible for distances as great as New York–San Francisco. The role such repeaters have played in conquering distance may be appreciated from the fact that the 40,000 repeaters existing in 1925 have been multiplied more than twelvefold. The family of tubes employed in present repeaters embodies sweeping improvements over 1925, and includes many new types especially adapted for use in carrier and radio systems.

Another basic element of the transmission advance is one born to blush unseen as far as the public is concerned. I am referring to the negative feedback amplifier which was invented by Harold S. Black, a member of Bell Laboratories' staff, in 1927. His invention is second in importance in telephony only to that of the three-element tube of deForest. As more and more amplifiers are connected in series, which is necessary as the length of the transmission path increases, minor imperfections in each amplifier become of major concern.

These imperfections are largely additive and unless minimized, place a limit on the number of amplifiers that may be used in series and thereby place a limit on the length of the transmission path. Today a long transmission circuit may include a thousand or more amplifiers, each one introducing a thousandfold amplification and each one capable of causing objectionable instability or distortion. Black took a small part of the output of an amplifier and connected it back to its input with reversed phase. He thus reduced the distortion produced by the amplifier a thousandfold or more, and he correspondingly decreased the instability occasioned by such factors as variation in power supply and tube aging. This negative feedback principle is now applied almost universally to amplifiers used for any purpose. It is no exaggeration to say that without Black's invention the present long distance network would not exist. Many of the industrial and military applications of amplifiers would also not be possible.

In addition to serving as an amplifier in telephone lines, the vacuum tube has enabled the transmission engineer to establish a comprehensive technology for all phases of long distance telephony and provided means for maintenance of the qualities of the transmission path essential to good service. Vacuum tubes used in measuring equipment as generators of electric oscillations, as amplifiers and as detectors have provided the ability to make precision measurements of line characteristics and of the various kinds of distortion incurred by the feeble telephone currents. These results, together with fundamental advances in the field of network theory, have made possible such precise compensation of transmission defects that conversation over thousands of miles may be carried on with practically no effort on the part of the talker or listener.

Still another basic element in the long distance transmission picture to which the high vacuum tube has made major contribution is the process known as modulation. This is a process whereby the frequencies composing a voice wave, or some other signal wave, are combined with a high frequency, known as a carrier, and shifted to another position in the frequency scale. Modulation has made possible carrier systems in which the electric currents of a number of different conversations are combined into a single high frequency current and transmitted as a unit over a single transmission path. At the receiving end the electric current of each conversation is sorted out by means of electric networks and transmitted to the appropriate called party. Most of you participate almost daily in one of the significant applications of the modulation process in multiplex or many-channeled transmission; because it is in just this way that numerous radio and TV programs are distributed throughout the nation, and you take your pick on your radio or TV receiver.

Thirty years ago carrier systems were used in a small way to increase the circuit capacity of open-wire lines. Each carrier system provided, on one open-wire pair, three or four extra conversation circuits—we usually call them channels—in addition to the ordinary voice circuit. Today, through modulation, as many as 16 telephone channels are derived from a single open-wire pair. More importantly, during the late thirties the carrier technique was extended to cable. From 12 to 24 two-way channels are now obtained on two ordinary cable pairs, one for each direction of transmission.

Through the use of a special type of conductor, called a "coaxial," the multiplication of circuits by means of carrier has been greatly extended. The conductor we call a coaxial consists essentially of a small copper tube or pipe about the size of a lead pencil, with a wire supported in its axis by dielectric washers. Using amplifiers of the feedback type spaced at intervals of a few miles, an extremely wide frequency band can be transmitted over one of these coaxials. It is as though a complete radio spectrum were contained inside the pipe.

In fact, in its early days, the coaxial idea was often referred to as a "pipe dream."

The coaxials are used on a double-track basis, one for each direction of transmission. The latest advance in coaxial systems, first introduced in 1952, provides on a pair of coaxials either 1800 telephone channels or 600 telephone channels plus a television channel in each direction.

Radio is in the carrier multiple-circuit act too, and in a big way. By way of background, we might recall that in 1925 there was only one commercial radiotelephone circuit anywhere in the world. This was between the California coast and Catalina Island, a distance of some 30 miles. I scarcely need to remind you of the numerous kinds of radiotelephone service we have today—between continents, across natural barriers, to ships, to moving vehicles and in all manner of other situations. The radio application I do want to mention is that of repeatered radio systems to provide wide frequency bands usable in the same way as coaxials to provide either large numbers of telephone channels, or television channels for the broadcast networks. These radio relay systems, as they are called, use extremely high frequencies known as microwaves. The radiated energy is not broadcast but instead is concentrated by a specially shaped antenna in a narrow beam, which travels in a straight line to the next repeater station, some 30 miles distant, in much the same manner that a searchlight projects a narrow light beam. This feature makes it possible to reuse the same frequency in different locations.

By means of multichannel carrier and radio systems, we have achieved a sort of mass production of telephone circuits. As is usual, mass production provides the key to economy here. The cost of a transmission path is divided among the number of circuits that it can transmit. Moreover, concentration of large numbers of paths on the same route yields further large economic advantage through their sharing the various common elements of cost, such as right-of-way, installation, line maintenance, radio towers, power supply, and the like. There seems indeed to be a rough economic law that applies to such situations. If we multiply the number of circuits on a route by ten, the cost per circuit is divided by about four. So it is not surprising to find today many routes each having a concentration of thousands of circuits.

However, we must move on. In addressing this Society at its 1947 Philadelphia Dinner, the man whom we honor tonight closed his speech with these words: "The past is fine if we do not spend too much time thinking about it. Tomorrow is the thing." So let me now, albeit with some diffidence, venture into the occult arts and attempt to forecast the future. Fortunately, this is not quite as difficult as was predicting whether the Dodgers or the Yankees would win the World Series. In modern science, even more clearly than in other affairs,

the seeds of the future lie in the present. Here, if anywhere, coming events cast shadows before.

We talked before about the two devices symbolic of the era behind us—the relay and the vacuum tube. Each one of these has been amazingly useful. Each has given birth to a vast art, and yet each one has grave limitations. To put it bluntly, the vacuum tube is inefficient and the relay is slow.

Both of these difficulties are overcome by a new device, the transistor, invented at Bell Laboratories a few years ago. This device is one of those big break-throughs in science that occur only at rare intervals. Just as the vacuum tube and the relay symbolized the past era, the transistor will symbolize the era beginning to unfold. Through better understanding and manipulation of the basic properties of matter, we have learned how to take semiconducting materials such as germanium and silicon, reduce the impurities to less than a part in 10 billion, so that we have the purest substance in the world, then add impurities such as phosphorus, boron or arsenic on a controlled basis, in an amount of a few parts in a million and thereby obtain a new and highly efficient amplifying device. This tiny amplifier—tiny in physical size and power consumption—is destined to be the giant of the coming era in electronics. Not only in telephony but in almost every area of industry, business and military weaponry will its effects be large.

The amplifying efficiency of the vacuum tube is only a fraction of a per cent. To handle telephonic powers which are only some thousandths of a watt, the vacuum tube needs about a watt of power to heat the filament, not to mention the high voltages on the other electrodes. The transistor, on the other hand, requires no heat to make it work. It functions with little power, something like a hundred-thousandth of that for a vacuum tube. It requires only a few volts for its functioning in contrast with the hundred or so volts required by the vacuum tube. Not only is the transistor itself very small, but the electronic components associated with it can be correspondingly miniaturized. Thus the size of electronic apparatus to perform a given function can, by transistorizing, be shrunk by a factor of five or ten to one, and the required power correspondingly reduced. Costs will shrink too, though not in direct proportion.

Important as it is to reduce the cost of facilities that provide present services, transistors will do much more. They will open up completely new fields. Carrier systems with transistors will be economical for still shorter distances. Heretofore, the costs of vacuum tube operation have limited the economic field of carrier to transmission distances greater than some 15 miles. In time, transistor economics will remove all barriers to carrier systems applications. The use of transistorized carrier in local plant trunk circuits, in subscribers' lines and in station

sets, will bring lowered costs, improved transmission and opportunities for completely new services.

Going to the other transmission extreme, it is definitely to be expected that transistors will some day provide the amplification for submarine telephone cables, where submerged vacuum tube repeaters are just now being applied in the first transatlantic telephone cable. The transistors will permit much wider frequency bands, giving more telephone channels, and should also make it possible ultimately to transmit television between continents.

Transmission in the new era will be favorably affected by a completely new philosophic concept known as information theory, largely developed at Bell Laboratories by Dr. Claude Shannon. This is a complicated mathematical concept which I shall not try to explain. In essence it tells us that all information can be expressed in terms of pulses. The concept will have far-reaching consequences. For example, we can look forward to carrier systems in which pulses transmit the voice waves. Channels can be combined not by interleaving in the frequency range, but by the interleaving of pulses spaced only a millionth of a second or so apart in time.

I could go on to list other things emerging on the frontier of basic science. Dielectric materials with extraordinary new properties are being obtained by precise control of the size, weight and arrangement of molecules. There are devices employing new magnetic materials in which atoms are regimented in orderly arrays whose spacings are established with accuracies of a few billionths of an inch. By virtue of these and other discoveries, new radio systems will provide wider frequency bands, hence more channels with the consequent lower cost per channel. I think I am quite safe in predicting also a hollow tube waveguide transmission system in which two hollow pipes associated with appropriate electronic circuitry will handle tens of thousands of voice circuits and hundreds of TV pictures.

Instead of trying to forecast more of the progress of transmission in the years ahead, I should like to return to the switching area to see what we may expect there. As I mentioned, a relay is slow. How slow? Well, á relay requires some thousandths of a second for its operation. Of course, if we measure by the standards of the human senses, this is fairly rapid. It falls in quite another class from the proverbial standard of speed—"quick as a wink." Though the ladies in the audience may profess no concern with the subject of winks, the men who have encountered this behavioral phenomenon may be interested to learn that we have made some laboratory observations bearing upon it. We find that the interval needed to operate a relay is only about one-fiftieth of the time consumed by a normal kind of wink.

Nevertheless, in today's electronic terms, a relay is slow. We now have transistors and other electronic switching devices that operate,

not in thousandths, but in one or two millionths of a second. In other words, these devices are a thousand times as fast as a relay. Just think of it. In a millionth of a second we are now able, not only to switch something, but even to perform a more complex operation involving choices based on conditions existing at the instant. What this means is that no longer must we set aside a large complement of apparatus to serve a single customer during the entire period of his call, or even a substantial part of it. Electronic equipment can be time-shared among a large number of customers who are served by it in such rapid succession that each one believes he is getting continuous and exclusive service. Through these high-speed techniques growing out of modern electronics, the size and amount of equipment required to perform the switching function will be greatly reduced.

The space required by the first electronic switching centers will be about one-fifth that of the corresponding standard relay or electromechanical system. The enormous decrease in size of equipment is due not only to the thousandfold increase in speed of operation made possible by electronics, but also to the miniature size of the transistors and the associated circuit components. The power consumption of the electronic central office will also be greatly decreased since the power required to close a relay contact is some hundredfold more than that required for the corresponding function when performed by a transistor or other solid state electronic device. For many years, vacuum tube electronic devices have been capable of performing all of the switching functions of the relay or electromechanical systems. Vacuum tube electronics provides the same speed advantage as does the solid state electronics. This advantage, however, is more than offset by the large power consumption, large physical size, and relatively limited life and reliability of the vacuum electronic devices. Even with the many functional advantages of electronics, its application to switching had to await the advent of the solid state electronic devices. Their small size, low power consumption, and reliability with indefinite life, combine with the higher speeds of electronic operation to provide the framework for a revolution in switching technology. This revolution will provide large economies and make possible services of broader scope over the telephone network.

The solid state electronic devices, spearheaded by the transistor and aided by many other solid state devices that time does not permit our discussing, are the contributions of research of recent years that will make possible communication services of much wider scope and large economies in the cost of facilities, their operation and maintenance.

We have spoken of this as a revolution. Actually, it is revolution through evolution, for these changes will not come overnight. The present telephone plant of the nation has a value of some $15 billion. The service advantages and the economies of the facilities of the new electronic era, as large as they will be, will not be of such proportion to justify a very rapid obsolescence of this existing and highly service-

able plant. Rather, the new construction, which is now proceeding at a national level of $1.5 to $2 billion annually, will consist more and more of the electronic facilities of the new era.

Challenging and most difficult tasks await the men of research and engineering in the integration of the facilities of the electronic era with the facilities of the past in such a way that there is compatible, trouble-free, and effective interconnection of the old with the new.

I shall stray a little to point out the new things made possible by solid state electronics and applications of information theory in other areas of our economy. Solid state electronic devices, coupled with the application of information theory, will greatly accelerate the applications of automation in business and in industry. An increasing amount of the routine operations of the office and the factory will be done automatically under the programmed control of large scale solid state computers, popularly and inaccurately called "electronic brains."

It is not appropriate to this presentation to discuss the tremendous values to our society and the accompanying social problems that these developments will provide. However, it is appropriate to point out that this wholesale application of automation to business and industry will place new and added demands on the transmission networks of the nation. The transmission between units of business and industry of suitably digitalized business and industrial data will be increasingly required in the new era of automation. Inventory, production, payroll, and industrial control information, for example, will flow between the headquarters of a corporation and its widely separated branches. Many of the widely separated operations involved in these procedures can be most effectively and economically done by transmitting coded data to a central data processing center where essential operations will be performed on the data. The processed information will then be transmitted to its source and to other centers interested in its use.

The remarkable growth in the use of the telephone by the American people over the past 30 years has been detailed. Examples of the role of research and technology in making this growth possible have been presented. An examination has been made of some of the new knowledge recently acquired through research that has not yet had technologic implementation. From this glance, it has been concluded that there lies ahead an even greater expansion of telephone usage and the scope of its service in the next few decades than in the past ones. It has been stated that a revolution through evolution is in the making. I hope that the facts presented will justify to you these conclusions.

Finally, I wish to bring to your attention the growing importance of all research in the physical sciences and the technology that implements its findings to the continued well-being and preservation of our society. The story of telephone research and technology presented this evening well illustrates two areas of such contribution that are of greatest significance.

The substitution of machines for man in performing the productive tasks of our society has been in progress, and with increasing tempo, since the birth of scientific research some 400 years ago. It is obvious that as the fraction of the total burden of productive tasks that are assumed by machines grows, the amount of time available to man for leisure and for his cultural development will increase. Machines, through making available to an ever-increasing fraction of the members of our society this freedom from toil, are providing expanding opportunities for leisure and cultural development.

The telephone research and technology presented well illustrate this contribution. The development of automatic means for the interconnection of telephone subscribers in these past 30 years has made it possible to provide the interconnecting service for some 56 million telephones with only some 1.45 times the personnel required for the 17 million subscribers of 1925. Solid state electronics gives promise of major extension of such automation, not only in telephony but also throughout all business and industry.

The conservation of the elements of the earth's crust, through the development of facilities requiring much less of them, adds greatly to the assurance of a continuing supply for the coming generations. This conservation process is further implemented by the development of synthetics—composed principally of elements carbon, hydrogen, oxygen, and nitrogen, which occur in unlimited amounts—that can be substituted for elements of more limited supply in the facilities that implement our living. And finally, conservation is achieved by the substitution of more abundant elements for those in more limited supply.

Telephone research and technology illustrate each of these facets of conservation. Solid state electronics will make more than a fivefold reduction in volume of material required in switching or interconnection. Broadband transmission systems, made possible by modulation, enable one equivalent conducting pair to carry increasing numbers of telephone conversations. Tens of thousands carried by a waveguide pair can be envisioned. Polyethylene, a synthetic, principally composed of carbon, hydrogen, and oxygen, is replacing lead in cable sheathing. And finally, the use of iron and other abundant elements is minimizing the use of scarce nickel in the magnetic elements of telephone facilities.

Research and technology are, therefore, the best insurance for the future of our society. Its continued existence, and certainly the continuing increase in its well-being, are primarily dependent upon research and technology. I am sure that Philip Staples, in whose memory these lectures were established, would join with me in saying that for the preservation and well-being of our society it is a primary responsibility of each generation to provide an environment conducive to the greatest possible strength in basic and applied research and technology, and in which they can make the largest possible contribution.

THE STRATEGIC AIR COMMAND *

BY

MAJOR GENERAL R. M. MONTGOMERY [1]

In order to put my discussion of the Strategic Air Command into the proper perspective, I would like to say a few words about the various combat commands in the Air Force. As most of you know there are three major commands.

First, there is the Air Defense Command, whose units are equipped with interceptor fighters which are located in various areas around the country. These fighter units are tied in with our Ground Observer Corps and our radar network. The job of the Air Defense Command is to intercept and destroy ener y aircraft before they reach their targets in this country. Under the 137 Air Force Wing program which will be reached by 1957, ADC will have 34 wings.

Second, the Tactical Air Command, which is responsible for training forces for operating in combat theaters. Their main wartime task would be to maintain air superiority over the battlefield and give close support to the troops on the ground. TAC will have 49 combat wings.

Finally, the Strategic Air Command—SAC, as we call it—is the long-range bomber force of the United States. SAC was organized in 1946 and was assigned the job of being ready to conduct long-range strategic air operations anywhere in the world. SAC will operate with 54 combat wings.

This evening, I thought I would select a few of the questions which are often asked us and answer them as we go along.

One of the questions usually asked is: *Why do we have a Strategic Air Command in the USAF and what is its job?*

To answer this question, I would like to go back in time a few years. The recognition of the need for a portion of our Air Force to concentrate on strategic bombing grew out of our experience in World War II. You will recall the destruction caused by our bombers against Germany and Japan during World War II. You will also recall that it took three long costly years to build up our bomber force—years during which our own home industries were not molested by enemy air attacks.

Two significant military facts emerged from World War II. One was the development and utilization of long-range bombers and the other was the development of the atomic bomb.

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These two—the long-range bomber and the atomic bomb—opened the way for the delivery of man's most destructive weapon to the very heart of an enemy nation.

Our Air Force planners decided to capitalize on these two developments and directed the establishment of the Strategic Air Command. In view of the time it took us to build a bomber force during the last war and the fact that our homeland could be attacked immediately in a future war, they also directed that the SAC must be a force in being—not on the drawing board—and it must be prepared to retaliate on a moment's notice.

Strategic air operations are extremely long-range air strikes designed to knock out the source of enemy air power, such as his fuel supplies, weapons stockpiles, airdromes and the bombers and fighters they support, as well as his industrial complexes that supply the sinews of war. Industrial targets include factories which make steel, tanks, guns, aircraft and electronics equipment; railroad centers, and so forth. Such attacks are designed to destroy the ability of an enemy to wage war. You might compare strategic air operations with an attack against the brain of the octopus rather than against individual tentacles. By going directly to the control center, the octopus can be destroyed without attempting the long and often costly process of trying to destroy each individual tentacle.

In summary, the job of SAC is to conduct strategic air operations on a global basis, and to deliver the maximum destructive power to the war-making potential of the enemy nation. Our combat operations are based on the premise that the fastest way to end any war is to deprive an enemy of the means, as well as the will, to continue the fight.

How is SAC organized and where are its bases located?

Commanded by General Curtis E. LeMay, the Strategic Air Command is organized into three combat air forces and three overseas air divisions. The headquarters of the air forces are located at March AFB, Riverside, California; Westover AFB, Chicopee Falls, Massachusetts, and Barksdale AFB at Shreveport, Louisiana. Each force has its own bomber and reconnaissance wings so that it may operate independently if necessary.

Our overseas divisions are located in England, French Morocco and Guam. These air divisions command the bases which are assigned to the Strategic Air Command in those countries.

Each of these subordinate headquarters—the three air forces and the three air divisions—report directly to SAC Headquarters which is located in Omaha, Nebraska.

Bases in the United States which are commanded by SAC are spread from one end of the country to another. For instance: In Washington we have 1 base; California—3; New Mexico—1; Arizona—

1; Texas—5; Kansas—2; Nebraska—2; South Dakota—1; Idaho—1; Maine—2; Massachusetts—1; Ohio—1; Florida—3; Georgia—2; Louisiana—2; Missouri—1; Montana—1; Arkansas—1; Oklahoma—1; and Puerto Rico—1. In the foreseeable future we will have additional bases in New York, New Hampshire and Oklahoma.

So you can see that the SAC Headquarters is the Control Center of a vast world-wide network of bases spread across the United States, extending to England and Africa and to the far reaches of the Far East theater.

What type of aircraft does SAC use?

SAC is currently using three basic bomber type aircraft and one fighter type.

Our medium bomber, the B-47, has six jet engines. It is in the 600 mile per hour class and is our first truly jet bomber. It weighs some 92 tons at take-off, carries 17,000 gallons of fuel and is manned by a crew of three. This crew is composed of an aircraft commander, pilot and an observer. The B-29, which has now been replaced in all our medium bombardment and reconnaissance wings by the B-47, carried a crew of 11. This reduction in the number of personnel does, however, require that our people be more highly trained, since all of the duties formerly performed by 11-man crews must now be performed by three.

The B-36 is our intercontinental bomber. It has six conventional type engines and four jet type engines. It weighs at take-off 179 tons. It can carry an 84,000 pound bombload and is manned by a crew of 16 people. The B-36 engines develop approximately 44,000 horsepower on its bombing run.

The successor to the B-36 is just now being delivered to the Strategic Air Command. This is the B-52 bomber—a true heavy bomber, powered with eight jet engines, each delivering 10,000 pounds of thrust. It will operate at more than 50,000 feet altitude, and fly at more than 600 miles per hour. It has a cruising range of over 6,000 miles, and can be refueled in flight to extend this range.

In SAC we also have jet fighter aircraft, the F-84F Thunderjet, which can escort our bombers and also participate in the defense of our airdromes. The swept-wing "F" is in the 600 mile per hour class, and also has a bombing capability.

In addition to these combat type aircraft, we of course have support aircraft, which help carry supplies to the fighting units. Included in this category is the C-124, which weighs 100 tons at take-off and is capable of carrying two Greyhound buses.

The B-36's and B-47's are used also in our reconnaissance wings which will provide necessary photography and other reconnaissance data.

One aspect of the B-47 which makes it such a good bombing vehicle

is that its range can be extended by air refuelings. We have built a sizeable tanker force for this purpose. This force consists principally of the KC-97, a tanker version of the Stratocruiser, and will soon be augmented by the KC-135, an all jet tanker. Our fighter aircraft also are capable of taking air refuelings.

Since the range of our B-47's can be extended by air refuelings, the practice of refueling medium bombers—and our fighters—in the air has become as much a part of our training as take-offs and landings. At our current rate, we are making approximately 142,000 hookups a year with tanker planes at predetermined rendezvous points and transferring more than 150 million gallons of fuel yearly. This averages out to a refueling operation each $3\frac{1}{2}$ minutes day and night around the clock.

Refuelings are conducted day and night, for fighters and bombers, in good and poor weather. We do not normally refuel where the weather is so bad we cannot make visual contact. In such cases, the refueling area is moved to a patch of sky where the weather is better.

We can and do refuel aircraft on many missions more than once and if a mission requires three or four refuelings, they are accomplished. The limitation here is crew fatigue. It requires hard work and highly precise formation flying, but it's being done consistently and safely. More than 98 per cent of all refueling attempts are successful. What failures there are result from equipment malfunctions.

What kind of training program do SAC crews undergo?

In order that we will know that our air crews are able to perform their assignments in time of war, SAC has developed an extensive training program. Under this training program, each individual crew member must periodically accomplish a specified quantity of training in his specialty. These requirements, which have been developed over a period of several years, insure that crew members spend their time in training which will do the most to improve their effectiveness in combat. How well each crew member performs his duties is measured on training missions which closely simulate actual combat conditions. Data collected from mission reports enable commanders to determine where the strength or weakness of each crew lies and where greater emphasis must be placed in future training.

To see how this system works we can look at a typical example: A crew must make a given number of simulated bombing attacks against individual industrial targets in or near our major cities. These targets are selected to represent as realistically as possible the type of enemy target that they would be called upon to bomb in case of war. Each of these simulated bombing attacks is scored and evaluated by means of a special radar station on the ground which plots the course of the bomber, then on a signal, the course of the bomb—and several minutes later can indicate the point the bomb would have landed had

one actually been dropped. If the bombing reported for one or more of these attacks is beyond acceptable error, we have an immediate indication that greater emphasis should be given to training designed to increase that particular crew's bombing accuracy.

SAC crews are continually mock-bombing our industrial areas—daily, nightly and in all kinds of weather. Normally, they are not detected by the populace below because of the high altitudes at which they fly. The necessity of this training becomes apparent when we consider the stakes involved, and realize that our striking forces must be trained to a point of readiness which makes them immediately available and capable of performing their war mission.

Similarly, the crew must be trained to navigate to any point in the world, to defend itself against enemy attack, and to perform all of the many other duties necessary to insure the success of the primary mission—the destruction of enemy targets.

To integrate crew training and unit training, each bombardment wing is periodically required to fly a simulated combat mission as a unit. Missions of this type involve the simultaneous participation of a large majority of the crews available to the unit. Insofar as possible, they duplicate in detail an actual combat mission of the type which might be required in the event of war. The results give the unit commander, and the commanders to whom he is responsible, a measure of the unit's strength and capability to function as an integrated combat force.

In each of four designated months, crews and units are exempted from the fixed training requirements previously mentioned. These so-called "special" training months are provided to break the monotony of repetitious training and to give the unit commanders an opportunity to experiment with new tactics, adjust operations to seasonal conditions, and to concentrate on those phases of training where correction of deficiencies is required.

General LeMay summed up our training concept when he remarked that "the only difference to the Strategic Air Command between peace and war is where we drop our bombs."

Equally important to the technical proficiency of the crew is the morale of its members and its integrity as a unit. Every effort is made to see that all members of a crew are compatible and can work together smoothly as a team. To maintain crew integrity, all of its members are even placed on furlough simultaneously.

Describe the Average SAC Combat Crew Commander

The average bomber commander is not as young as most people would guess. He is a mature technician of about 32 years, and bears scarcely any resemblance to the young pilot who fought the last war. He has been married over five years and has two children. He makes

a modest salary and spends a sizeable percentage of it on life insurance. He has been in the Air Force about eight years and has never had a job which did not involve flying. During this time he has flown 4,000 hours—the equivalent of roughly one million miles. He has been in the Strategic Air Command a little over four years.

The airplane commander of a crew is a very busy individual. Naturally, his crew participates with him as a team. Each week they fly at least one training mission, of approximately 15 hours' duration. This mission requires ten hours of planning and preparation plus another four hours for inspecting the airplane and all of its equipment prior to take-off. The post flight duties and a critique of the mission to determine whether it was successful require another four hours, and the crew spends an additional fifteen hours per week in a professional ground school. All this adds up to 43 hours per week devoted directly to the flying business. There are, of course, many other routine military tasks which must be performed and which take up more of his time. The work week is not only long, but the hours are irregular. It is not uncommon for official visitors at our bases to lose enthusiasm about going on a training mission when they learn that the B-36 airplane taking off on Thursday will not land until some time Saturday.

Our crew members are also something of world travellers. They spend about three months out of each year at some overseas base. They are just about as familiar with the far reaches of the South Pacific and the rugged weather of the North Atlantic as they are with the plains of the Midwest and the great Gulf area of the South. In addition to the overseas stint each year, they spend roughly three months away from their home station engaged in various phases of their technical training.

An effective military organization of strength and permanence, like every other organization, is in the final analysis á matter of men. In order to maintain the type of professional force we need, we must attract and hold a fair share of the talented manpower of the country.

We are not doing this at the present time. Approximately 70 per cent of the Strategic Air Command enlisted strength is on its first enlistment. There are many reasons for this, of course. The Strategic Air Command is certainly not a convenient place to serve. The hours are long, the work hard and exacting. People are away from home and families much of the time.

Couple this with low pay, inadequate medical attention for their dependents, poor or non-existent housing, and you see the result.

As soon as we have paid the bill to train a man to do his job, he leaves to take up a more desirable position in civilian life. We can never hope to hold these individuals until we offer a career in the service commensurate with what is offered in civilian life. It will cost the taxpayers *two billion* dollars in 1955 to train replacements for

the people leaving the military service this year and next. These are the patriotic citizens who volunteered for service early in the Korean War and who no longer want to remain in the service.

One of the most important factors in determining whether or not we will be able to attract and hold adequate numbers of highly motivated, highly skilled people is the attitude, the interest and support of communities near our bases.

A typical two-wing B-47 Stratojet bomber air base represents a capital investment of more than $300 million, in addition to the cost of land and construction. The B-47's and their refueling tanker squadrons represent about $240 million of this total investment.

The training investment in personnel amounts to over $52 million. About $15.5 million is also invested in support equipment.

A strong striking force is the compelling counterthreat that can carry a war back to the potential enemy's doorstep. Potent and poised, it is capable of convincing Russia of the futility of starting a global war. It constitutes an indispensable factor in preserving world peace.

How does SAC keep its far-flung operations efficient and economical?

We look upon SAC as a business enterprise, and have applied many of the scientific control methods common to modern industry. As you can imagine, the maintenance of our complicated aircraft with their electronics systems cannot be accomplished by guess work. We have borrowed from airline techniques and from automobile assembly line techniques to develop a precise and efficient aircraft maintenance system. This system enables us, through centralized control, to reduce expensive equipment and the numbers of expert technicians required.

It is no longer sufficient for a military commander to merely lead troops. He also must be able to apply sound management to the use of manpower, equipment and money available to him. General LeMay has been running a series of schools for our commanders, reviewing the technical procedures of sound financial management.

This attitude of cost consciousness has permeated the entire SAC structure, and is daily producing streamlined procedures and more work with reduced resources. When I say that the sum total of savings realized through hundreds of management improvements each year amounts to several million dollars, your natural question may be, "Why did you wait so long?" Our only reply is that no one is ever so good that they can't improve, and SAC looks upon ways and means to get the greatest possible return for each tax dollar as its greatest challenge.

In closing, I would like to tell you something about our realistic operations which are designed to keep our forces ready to go at all times.

Modern developments in warfare demand an ever-increasing degree of flexibility. We of the Strategic Air Command have developed to a fine point the art of deploying our forces on a global scale as changing situations may demand.

Our B-47 wings make regular training flights to England and North Africa. During these deployments SAC has set what I believe are some impressive unofficial distance and time records. For example, early in 1954, the 22nd Bombardment Wing based at March Air Force Base, Calif., returned from a 90-day temporary duty period in the United Kingdom. The Stratojets of the wing flew non-stop from a base near London to their California base in 12 hours and 38 minutes. This is a distance of 5,860 miles and a true example of how our air refueling operations extend the range of our bombers. Routine crossings from the United States to England have been made by B-47's in considerably less than five hours.

Another example of SAC's "extended range—speed package" is a flight from California to Japan of three B-47's led by Maj. Gen. Walter C. Sweeney, Fifteenth Air Force Commander. The flight took less than 14 hours for the 6700 mile distance, and is the longest point-to-point nonstop jet flight ever attempted. In December 1954, General Sweeney reversed his direction and flew from California to England nonstop in 10 hours. The distance is 5740 miles. Air refueling of course was used in both flights. Flights of this nature surely prove the axiom that the world has grown smaller in the jet age.

Our fighter wings also have deployed across both the Atlantic and Pacific. In August of 1955, 12 F-84 Thunderstreaks of the 27th Fighter Wing landed at Bergstrom Air Force Base, Austin, Texas, after completing a 5,118 mile non-stop flight from England in ten hours and 48 minutes. Multiple air refuelings made possible this record-breaking flight.

Late in 1954 the 92nd Bombardment Wing conducted the first deployment of B-36's to the Pacific area, using Guam as their base of operations.

For the past eight years there has not been a day when some SAC units were not on rotation in some area outside the United States. More than 90 per cent of the currently activated and equipped SAC units have undergone overseas rotational training.

We believe that SAC's capability to strike anywhere in the world on a minimum notice with atomic weapons has been the greatest deterrent to a major war.

SAC is the greatest force for peace in the world today. Teddy Roosevelt once said: "Speak softly but carry a big stick." SAC is that big stick.

AIR ION GENERATION, SEPARATION, METERING AND PHYSIOLOGICAL EFFECTS

BY

W. WESLEY HICKS [1]

ABSTRACT

This paper summarizes the result of extensive research into air ions, from the point of view of physics, biology, and therapeutic usefulness when breathed by humans.

INTRODUCTION

Air ions are positive or negative electrically charged molecules of gas or particles. This paper reviews the development of means for generating, separating, and controlling air ions at the molecular level and applying them clinically.

It is now some 200 years after Benjamin Franklin[2] related electricity to lightening and tried to bring his scientific findings to the aid of humanity. Today his theories still afford invaluable inspiration for basic investigations, carried out by modern medical researchers without Franklin's frustrations which he attributed to the absence of "advice of skilled physicians to direct treatment."

PHYSICS

When World War II started, my associates and I were investigating the positive and negative ion output of our electric heaters in which we use nickel chromium resistant type heating elements operating at elevated temperatures. Skilling (1)[3] had reported from Stanford that electric heaters produced atmospheric ions in equal numbers at temperatures around 2350° F. and more positive ions than negative ions at lower temperatures.

In our effort to control ion output within this temperature range, we turned, as soon as war conditions permitted, to the use of negatively charged, nickel wire mesh grids encompassing our standard vertical, hollow, core-type heating elements wound with nickel chromium coiled resistance wire, operating at temperatures under 1200° F. At the same time, we recognized the problem of supplying negative air ions in warm weather. The first solution sought was thermion emitters developed by our engineers (**2, 3**).

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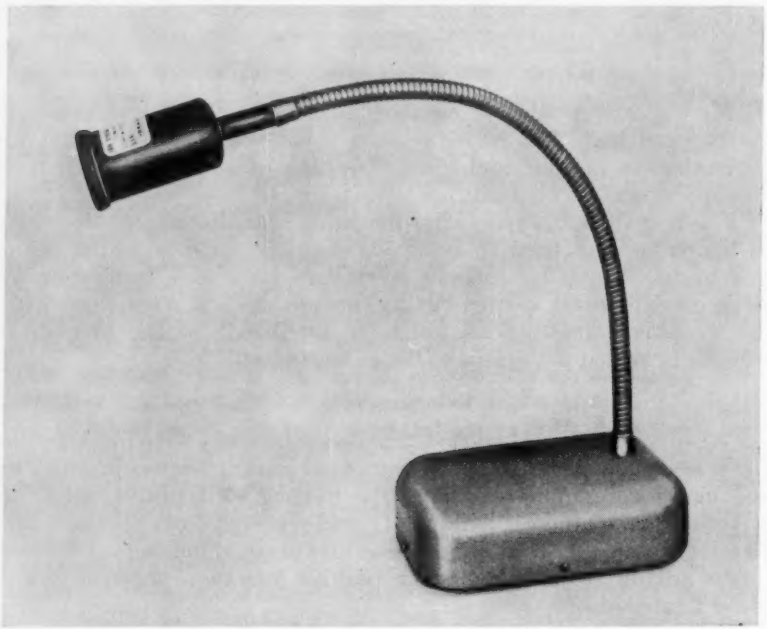
[1] President, Wesix Electric Heater Co., San Francisco, Calif.; Member, The Franklin Institute.

[2] See, for example: Otto Glasser, "Medical Physics," Vol. 1, p. 1467, Year-Book Publication, Inc., 1947; Hugh H. Skilling, "Exploring Electricity," New York, The Ronald Press Co., 1948, pp. 26–27; and *The Institute News* for March 1955, published by The Franklin Institute.

[3] The boldface numbers in parentheses refer to the references appended to this paper.

Having successfully developed simple, safe, inexpensive means for generating and controlling air ions free from ozone and nitrous oxide, our next problem was concerned with the development of accurate ion metering equipment. Our Stanford electrical engineering Fellow, Kamphoefner, contributed to the solution of this problem during the academic year 1948–49. His investigation was continued by our 1950 Fellow, Wm. Thon, and again by our 1953 E.E. Fellow, S. B. Hammond. with the help of Dr. Carroll (4).



Commercial type ion generator using radioactive emitter and 300-volt electrostatic separating potential.

The relatively short life of hot wire filaments of platinum and certain alloys was investigated by Martin who made a comprehensive study of various alloys as thermion emitters.

Difficulties inherent in the use of hot wire filaments for ion generation led to intensive study into the possibilities of ion generation by polonium. This study was carried on at our own laboratory with suggestions from Skilling. A simple, single electrode type of polonium generator was the outcome of this effort. The results are published by Skilling and Beckett (5) and confirmed more recently by Truman S. Gray at Massachusetts Institute of Technology.

From personal experience and empirical evidence, I have known of the therapeutic usefulness of negative air ionization for a long time, particularly on respiratory illnesses, including asthma, hay fever, and on high blood pressure. It was recognized that basic reproducible experiments had to be made under controlled conditions before ion generators were made available to the general public.

Martin (6), while working with hot platinum filaments, reported ion generation greatly affected both as to quantity and as to polarities by air pollutants. This observation was followed up by Robert Hessemer (7), who observed the different characteristics of various alloys when operating in combination with tobacco smoke as a common and representative air pollutant.

Continuing our sponsored studies at the University of New Mexico, Martin (8) investigated the generation of negative air ions by other radium isotopes, including Radium "D."

Beckett (9) has shown the effect of occupancy on ion density in a room and the influence of outside conditions on the ion level in artificially ionized, indoor atmosphere and discussed the effect of air ions on human health. His report on air ionization as an environment factor summarizes in a general way the results of our physics research to date.

Murphy (10) describes air ionization as the "missing link" between air conditioning and human health and points out that only by the generation of negative ions can ion density be maintained at a comfort level in an air conditioned room.

BASIC BIOLOGICAL INVESTIGATIONS

Having established the validity of our discoveries and theories in respect to generation, separation, and control of air ions, we stimulated studies already under way or sponsored additional studies concerned with basic biological investigations in twelve universities and medical schools. In these investigations, thousands of rats and mice and hundreds of hamsters and rabbits have been sacrificed, and more than 50 separate controlled investigations have been carried out.

Following the release of a report by Hansell (11), "Miscellaneous Developments in German Science & Industry," June 1945, and Fiat Final Report No. 899 (12), we had John Crerar Library make a comprehensive search of the existing literature concerned with the production and clinical use of air ions, resulting in 45 references.

The immediate goal of this phase of our research has been to establish beyond question that ions can have an objective effect on biological activities. It seemed desirable that pioneer research for such a purpose should be extensive rather than intensive, without overlooking the necessity for repeating each original test reported in the literature.

Although some medical doctors in this country have confused air ions with chemical ions, others have understood the physical properties of air ions and have found in them a fruitful field for research. At least one practicing physician has made a comprehensive and penetrating analysis of the biological and clinical effects of air ions, as one aspect of the weather influence on his patients. Dr. Edward E. Brown (13) in a series of published papers has given the results of investigations that he has been carrying on since 1940. He has endeavored to correlate atmospheric conditions, particularly during stormy weather, with the reaction of patients suffering from various illnesses, including respiratory troubles, rheumatoid arthritis, etc.

Many of our experiments had to be repeated at least once, because of the difficulty of controlling all relevant conditions, such as temperature, light, and humidity. Researchers well versed in animal experimentation nevertheless found difficulties in using delicate electrical measuring and recording instruments, some of which had to be especially developed for the tests. Currents as small as 10^{-15} amperes (one millionth of one billionth of an ampere) had to be measured.

In addition to the investigators whose publications are specifically mentioned, several other outstanding men of science have given us the benefit of their advice, each in his field of interest. Among this group, we feel especially indebted to Doctors Charles D. Marple, William Malamud, Michael B. Shimkin, A. P. Krueger, and Wm. C. Kuzell, and the late Clarence R. Strickland.

Some have assisted by suggesting lines of investigation. Others, in addition to their suggestions, have patiently carried out research in areas where there was little of established methodology to use for reference. Our purpose has been to ascertain through them the scientific basis of observations reported to us or observed by us.

Hansell, in a lecture at Brookhaven National Laboratory April 21, 1954, reported that he and Lindenblad, working at Rocky Point Laboratory (RCA) in 1930, discovered that negatively ionized air produced physical, mental, and emotional uplift and that positively ionized air produced powerful effects, physical, mental, and emotional. Summarizing reported specific effects of strongly positively ionized air, he lists discomfort, fatigue, headaches, dizziness, nausea, and faintness. Summarizing effects of strongly negatively ionized air, he lists comfort, optimism, exhilaration, good temper, friendly attitude, and relief for hay fever and asthma.

Growth

Danforth (14) investigated the effect of air ions on the growth of chickens. He found an increase in the rate of growth of chickens under negative ionization which was statistically significant as compared with those under positive ionization or control.

A pioneering study of the growth and weight of glands of rats under air ionization was made by Holloway (15). He studied long-term changes with exposures up to 72 days. His findings strongly indicated that air ions influence adrenocortical activity with some cyclical pattern.

Worden (16) investigated the comparable weights of selected organs of golden hamsters subjected to negative and positive air ions compared with controls and reported statistically significant differences. *T* values determined from the values observed show that atmosphere with an increased concentration of negative ions exerted a stimulating influence on the growth and ultimate relative weights of certain organs as compared with the same organs of control animals. An increased concentration of positive ions demonstrated no statistically significant values.

Cells and Tissues

Worden investigated the effect of positively and negatively ionized air on cells and tissue. His early study of cell growth with tissue cultures was followed more recently by a series of experiments with embryonic blastoderm sections.

Worden (17) reported that the carbon dioxide combining power of plasma was significantly increased in hamsters kept in negatively ionized air as compared with those in positively ionized air or in normal atmosphere.

Worden (18) also reported that the blood pH was also elevated in a negatively ionized group of hamsters.

Eddy and Sokoloff (19) reported that greater inhibition to tumor growth was achieved when rats kept under a negative ionization were given calcium.

Sokoloff (20) found that growth of transplanted tumors was inhibited in rats and mice under negative ionization.

Shikamura (21), studying under Dr. Danforth, found a lower rate of metastasis in negatively ionized than in positively ionized or non-ionized tumorous mice.

In a study of the effects of atmospheric ions and atmospheric contaminants on the pituitary-adrenal system of rats, Rinfret and Wexler (22), using histological methods for the study of adrenal changes, found that exposure to an atmosphere containing an excess of positive ions produced histological changes in the adrenal glands indicative of elaboration by the glands of both salt and carbohydrate regulating corticoids. They also reported dramatic stress effects of air ions on the pituitary-adrenal system. Recent unpublished reports by Griffin and Richardson (23) appear to confirm these findings and in addition report that air ions also affect the thyroid gland.

Nielsen and Harper (24) have reported that animals (rats) maintained in positively ionized air showed a statistically significant decline in succinoxidase activity of the adrenal gland. The effect on the adrenal succinoxidase was opposite to that of electric shock.

Stanley (25) compared the energy of ionized and un-ionized rats in self-propelled revolving cages. Rats in the negatively ionized cages showed greater activity than those in the control cages or in the positively ionized cages.

Plants

Giddings (26), experimenting at U. S. Department of Agriculture, Riverside, reported that cucumbers flourish under positive ionization, growing 48 in. during periods when the same type of plant in control cages grew only 30 in.

CLINICAL INVESTIGATIONS

Medical friends and others, including the writer, visiting universities and hospitals in Germany recently, found medical science well advanced in application of air ions to human health. Since our interest from the start of our investigation concerned human health, we have loaned scores of negative ion generators to physicians, engineers, bio-chemists, physicists, and others for pilot tests or experiments. Users report favorable effects of negative air ions on hay fever, asthma, sinusitis, or hypertension. In view of these early reports which seemed to confirm results reported in the literature, we have shifted our emphasis to clinical application.

Koller (27) commented that measurement of blood pressure of healthy individuals showed that after inhaling air with high concentration of negative ions from one-half hour to an hour the blood pressure is lowered 5 to 15 mm.

Swangard (28), reporting on the clinical effects of air ions in Germany, stated that over 30,000 air ion treatments were given between 1930 and 1945 and that 80 per cent of the patients were helped.

Dessauer (29) and Rajewsky (30) reported favorable effects of negatively ionized air breathed by patients on blood pressure, respiration, migraine headaches, and general fatigue, and the opposite effect when positively ionized air was breathed.

Basal Metabolism

In a limited pilot study using 11 normal subjects under negative ionization, McNaught and Michelson (31) found that all but two showed an increase in BMR from 21 to 70 per cent. Since this was an incomplete investigation using relatively crude equipment, we did

not take the reported results too seriously. However, the effects reported have aroused considerable interest and appeared to justify additional investigation of the effects of air ions on the BMR. Additional studies are under way.

Okada (32) reported an increase in gastric activity in persons exposed to negatively ionized air and a decrease in a positively ionized atmosphere.

Mayazaki (33) reports that ionized air shows a remarkable effect in diseases of the hypophysis and midbrain such as hypertension, emesis, bronchial asthma, and parietal headaches. He concluded that, although only negatively ionized air had been used for treatment, inhaling positively ionized air might be useful under some conditions.

Gorriti and Medina (34) report that 29 out of 30 high blood pressure patients subjected to negative air ionization reacted favorably. The average reduction in arterial pressure of patients treated exclusively with negative ion therapy amounted to 3.9 cm. of Hg, and in 5 patients subjected to a combined therapeutic and biological treatment reduction averaged 4.8 cm. of Hg.

Numerous and varied experiments have tended to confirm the effects reported by earlier investigators and definitely establish the fact that negative air ions have a physiological and therapeutic effect on respiration, circulation, the glands and the nerves. Clinical investigations aimed at determining the limitations in the effect of air ions of one or both polarities with or without drugs or aerosols are being actively continued.

Kornblueh, in a technical exhibition of negative air ion generation and metering at a recent meeting of the American Congress of Physical Medicine and Rehabilitation, demonstrated that indoor air may be artificially modified to provide a preponderantly negative ion density within a room.

Kornblueh and Griffin (35) report that in 1954, 27 hospital patients were exposed to the influence of negative ionization in an experimental room. Most patients with hay fever and asthma responded favorably to the physical alteration of the environment. Repetition of exposure during the ensuing season continued to show gratifying clinical results.

Dr. Biss-Grafschaft (36) reported to the Schwebestoff-technischen Arbeitstagung that unipolar negatively charged aerosols seem to increase the existing transitional phase of the autonomous nervous system as in the amplitude of a pendulum swing, while unipolar positively charged aerosols have a tendency to level changed reaction phases of the autonomous nervous system.

Todd (37) reported that a high school under his supervision, equipped with electric heaters combining negative ion generation with positive ion control, showed a commendably higher attendance.

CONCLUSION

Results reported above and preliminary reports from investigations under way encourage us to continue our investigations of the therapeutic effect of air ions on human health.

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Sub-Miniature Gyro-Compass Tested in Helicopter.—For the first time a true north-seeking gyro-compass of traditional battleship accuracy has been successfully operated in flight. For its initial flight, the beginning of a series of demonstrations to focus attention on the applicability of high-accuracy gyro-compasses over a wide range of military navigational requirements, the gyro-compass was mounted near the pilot in a conventional military helicopter. As regularly installed, it would be located out of the way, and only a repeater would be mounted with other instruments in the cockpit.

The gyro-compass, which has no magnetic reference, is no larger than a paratrooper's boots. It can be carried easily in one hand and is rugged enough to perform accurately in an Army tank operating in rough terrain. It has been developed by the Arma Division of American Bosch Arma Corp.

Concurrent with the airborne tests, carried out by the Engineer Research & Development Labs., Fort Belvoir, Va., a general exhibition to the military was undertaken by Arma as a pre-announcement showing of the division's advances in gyroscopics, exemplified by the Subminiature Gyro-Compass which is now in factory production.

Being proved are many facts which herald early solutions not only to the puzzling problem of all-weather, all-area helicopter navigation, but also solutions to many facets of navigating other airborne vehicles and land and water craft which are unable to accommodate the greater bulk of earlier high-accuracy gyro-compasses.

Most important, perhaps, is that environment on land or sea or in the air does not deteriorate the high accuracy of the instrument.

The compass neither has to be handled tenderly nor to be operated by skilled personnel. Also, it is not susceptible to magnetic storms, changes in magnetic structure of vehicle frame, and d.c. fields from motor or radar operation. In addition, it eliminates deviation corrections and permits high-latitude operations.

Although characterized as a "breadboard" demonstration, nothing was lacking. Installation and display packaging specific to helicopter and various other vehicle types is yet to come.

Details of the Arma subminiature gyro-compass are not classified and the instrument may be made available for commercial as well as military operations.

Nylon Lung for Respiratory Diseases.—A new portable respirator—a nylon lung—which is thought to be the smallest and most advanced machine of its kind in the world, has been invented by Electronic and X-ray Applications, Ltd., a London firm. Comprising a lightweight nylon jacket and a highly specialized pump-valve mechanism, the lung operates either from power mains or, in emergency, from batteries. The whole machine weighs no more than 80 lb.

One section of the equipment provides manually operated breathing. This component is watertight, buoyant and extremely strong and might, for example, be dropped from an aircraft into the sea for immediate use in lifeboats or aboard ship in cases of drowning or severe shock.

It is expected the nylon lung will help speed convalescence of patients recovering from respiratory ailments, since it enables them to move around fairly freely in bed, instead of having to lie supine, and to be comfortably transported from one place to another if necessary.

NUCLEAR RESONANCE FLUORESCENCE IN SOME HEAVY NUCLEI*

BY

FRANZ R. METZGER [1]

ABSTRACT

Using the Doppler broadening due to thermal agitation and the Doppler shift due to mechanical motion as means of restoring the resonance condition, nuclear resonance fluorescence has been observed from the following isotopes: Pr^{141} (145 kev), Hg^{198} (411 kev), Hg^{199} (209 kev), Hg^{202} (439 kev) and Tl^{203} (280 kev). From the magnitude of the resonance fluorescence effects the following mean lives τ_γ of the gamma-ray transitions have been calculated: $(3.0 \pm 0.4) \times 10^{-9}$, $(3.15 \pm 0.3) \times 10^{-11}$, $(1.2 \pm 0.4) \times 10^{-10}$, $(3.4 \pm 0.7) \times 10^{-11}$ and $(4.7 \pm 0.8) \times 10^{-10}$ second.

For the even-even nuclei, the angular distribution of the resonance radiation confirmed spin 2 for the excited state, and spin 0 for the ground state.

INTRODUCTION

The relatively long lifetimes of nuclear gamma-ray transitions cause considerable difficulties if one tries to adapt the well known atomic resonance fluorescence techniques (1)[2] to nuclei, that is, if one uses radioactive isotopes decaying to the element under study as the source of the exciting radiation. In the nuclear case the recoil energy losses in the emission and absorption processes are large compared with the natural line widths. This means that the exciting radiation is off resonance and that the cross section is very small. In order to observe nuclear resonance fluorescence, one has somehow to restore the resonance condition.

For heavy nuclei and for gamma rays of energies below 500 kev, the velocities of thermal agitation and of the motion of macroscopic bodies are sufficient to compensate, through Doppler effect, for the recoil energy losses. Moon (2) was the first to demonstrate clearly a resonance fluorescence effect in Hg^{198} using an ultracentrifuge to realize the necessary velocities. Malmfors (3) obtained with the same isotope an indication of a resonance fluorescence effect upon heating of the Au^{198} source. Preliminary results on several other iostopes have been reported on different occasions (4), but a more detailed description of the experiments was postponed in the hope of improving the accuracy and reliability. However, it is now felt that, due to the expiration of loan periods for scattering material and to difficulties in obtaining sources of very high quality, further improvements will not be forthcoming for a considerable length of time. It was, therefore, decided to report on the present status of the experiments.

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[1] Bartol Research Foundation of The Franklin Institute, Swarthmore, Pa.

[2] The boldface numbers in parentheses refer to the references appended to this paper.

GENERAL CONSIDERATIONS

For the following, it is assumed that the lifetimes of the gamma-ray transitions which are being studied are very long compared with the time between collisions of the recoiling nuclei with other atoms of the source. If this condition is fulfilled, any memory of the recoil from the radiation preceding the gamma emission is lost, and the emitted line has a shape reflecting the Maxwellian distribution of the velocities in the source. For this case the relationship between the average cross section for resonance fluorescence and the natural line width has been given (2, 3) for the experiment with the centrifuge as well as for the experiment using the heating of the source as the means of restoring the resonance condition. In both cases the influence of internal conversion and of gamma-ray branching had been neglected (5). If internal conversion and branching are taken into account, the average cross section for resonance fluorescence under reemission of the gamma radiation is slightly modified. For a scatterer at the absolute temperature T_1 and a source at the absolute temperature T_2 moving towards the scatterer with the velocity u, the average isotopic cross section for resonance fluorescence is

$$\sigma_{av} = \frac{g_2}{g_1} \cdot \frac{\lambda^2}{4\sqrt{\pi}} \cdot \frac{1}{E_\gamma} \cdot \frac{\Gamma^2{}_{\gamma_0}}{\Gamma} \sqrt{\frac{Mc^2}{2k(T_1 + T_2)}}\, e^{-\frac{M(E/Mc - u)^2}{2k(T_1 + T_2)}}. \qquad (1)$$

Here g_2 and g_1 are the statistical weights of excited state and ground state respectively, λ is the wave length of the gamma radiation of energy E_γ, Γ is the total width of the level, that is, $\Gamma = \Sigma(\Gamma_{\gamma\nu} + \Gamma_{\alpha\nu})$, $\Gamma_{\gamma\nu}$ being the partial width of the ν^{th} gamma transition originating from the level, and $\Gamma_{\alpha\nu}$ being the partial width due to internal conversion of the ν^{th} transition. M is the mass of the recoiling nucleus, k is Boltzmann's constant, and c is the velocity of light.

In the type of experiment performed so far, one actually measures the differential average cross section at a certain angle. In order to obtain σ_{av} from that measurement, one has to know the angular distribution of the resonance radiation. If the resonance fluorescence effect is large, the angular distribution can be measured. If the resonance fluorescence effect is so small that it is only practical to measure the differential cross section for the most favorable angle, the knowledge of the spins of the two states involved and of the multipole character of the transition is necessary for the calculation of the angular distribution. If J_0 is the spin of the ground state and J the spin of the excited state, the angular distribution is identical with the angular correlation of two successive gamma rays of identical multipole character in a spin cascade $J_0 - J - J_0$ (6).

Rayleigh scattering and Compton scattering are the two processes which contribute most to rendering the resonance fluorescence experiments difficult. The $(Z/E)^3$ dependence of the Rayleigh scattering

cross section makes the ratio of resonance fluorescence to Rayleigh scattering especially poor for the low energy transitions in heavy nuclei. Energy discrimination is of no use as far as Rayleigh scattering is concerned, since both Rayleigh and resonance-scattered quanta have the full transition energy. The Compton scattered radiation can in principle be eliminated by energy selective detectors, but the large intensity of the Compton scattered radiation together with the poor energy resolution of the presently used scintillation spectrometers makes this a formidable task indeed, especially for low energy quanta for which the relative energy loss upon Compton scattering is small. All these factors combine to limit the resonance fluorescence method to lifetimes shorter than 10^{-8} to 10^{-9} seconds. In favorable cases, that is, for transitions leading to isotopes of high abundance, a comparison with other more direct methods of measuring lifetimes is possible.

In all the cases investigated so far with the thermal method, the largest resonance fluorescence effect amounted to less than 20 per cent of the background. The main uncertainties are therefore statistical in nature. The source strengths cannot be increased at will; pile-up effects determine the maximum strengths.

It is clear that the sources should not emit gamma rays of energies higher than that of the transition under study. The Compton scattered radiation of even a low intensity, high energy branch can completely overshadow the elastic peak due to the main low energy transition. Moreover, the presence of a high energy component necessitates the use of a much longer absorber of the direct beam and thus reduces the solid angles.

EXPERIMENTAL METHOD

A. Thermal Method

The rapid increase of the Rayleigh scattering cross section for scattering angles smaller than 100° and the necessity of reducing the energy of the Compton scattered radiation as much as possible clearly call for geometries employing large scattering angles. Angles beyond ~150° demand impractically larger scatterers. The suitable scattering angles are thus comprised between ~100° and 150°. The general arrangement used in all cases is given in Fig. 1. The NaI crystal, which is part of a scintillation spectrometer, is shielded from the direct beam by a truncated cone or cylinder of Au or Pb. The height of the cone corresponds to approximately twenty half-value thicknesses, that is, the beam is reduced by a factor of 10^6.

The ring scatterer is between 6 and 12 in. in diameter; the diameter is mainly determined by the length of the shielding cone and the availability of the scattering material. For each experiment two ring scatterers are prepared. One of them consists of the material in which one wishes to produce the resonance fluorescence effect, the other is made

of a neighboring element. The two scatterers are usually matched at room temperature, that is, their thicknesses are adjusted until the counting rates due to the full energy quanta are identical within the statistical errors. The rings are of the same height and inside diameter and care is taken to choose substances of similar densities; this last precaution is especially important in cases where the source material is

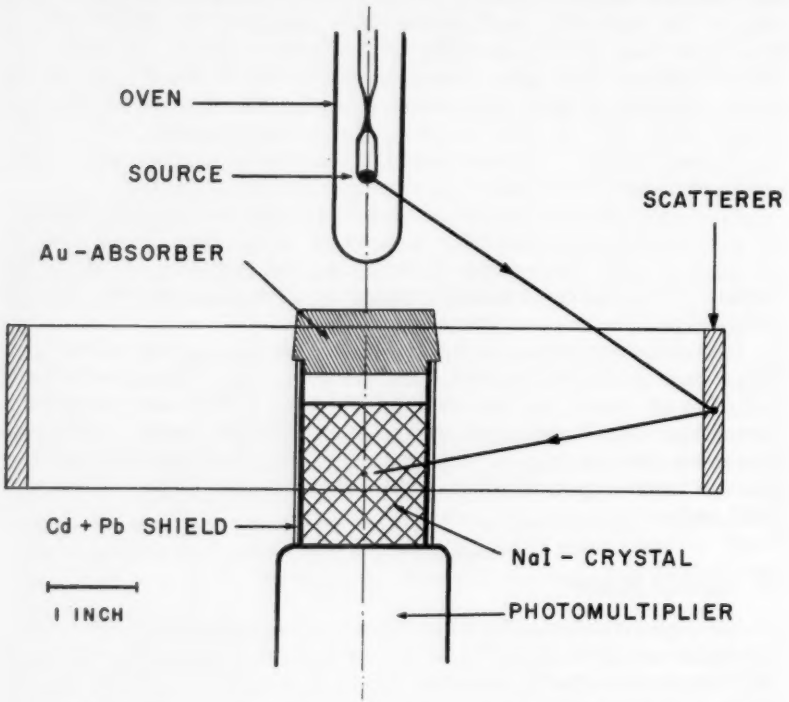

FIG. 1. Experimental arrangement for the thermal method. The diameter of the ring scatterer, the thickness of the Au-absorber and the composition of the Cd + Pb shield vary for the different isotopes. The figure shows the geometry used for $Ce^{141} \rightarrow Pr^{141}$. In this case, the Cd shield was $\frac{1}{32}$ in. thick, the Pb surrounding it $\frac{1}{64}$ in.

solid or liquid at room temperature and gaseous at the elevated temperature. For such a source the "center of activity" shifts upon heating and, unless all dimensions of the scatterer are identical, the differences due to the changes of the solid angles may become of the same order of magnitude as the resonance fluorescence effects.

Having matched the scatterers at room temperature, one is interested in any difference in the counting rates which develops upon heating (or cooling) of the source. The use of a comparison scatterer

eliminates slight changes in the counting rates due to expansion of the parts, changes in the self-absorption of the scource (3), shifts in the electronic equipment and so on, and enables one to measure the resonance fluorescence effect alone.

The radioactive material is sealed into quartz ampoules of approximately one ml volume. The sources are heated in a quartz oven wound with nichrome wire which allows oven temperatures of up to 1200° C. to be obtained. The temperature of the source is measured with a chromel P-alumel thermocouple.

The NaI crystal is usually surrounded with Cd and Pb absorbers which help to reduce the Compton scattered radiation and prevent the total counting rate from becoming excessive.

The solid angle subtended by the scatterer at the position of the source is calculated from the known dimensions. The scatterer detector solid angle is determined experimentally by moving a point source to representative positions of the scatterer and measuring the corresponding counting rates. Using the same setting of the scintillation spectrometer and the same absorbers, the source used for these solid angle measurements is then compared with the source used in the actual resonance fluorescence experiment.

B. Mechanical Method (Centrifuge)

The general arrangement used for the centrifuge experiments is shown in Fig. 2. The air driven and air supported rotor was copied from a design of Professor J. W. Beams (7) of the University of Virginia. The diameter of the aluminum rotor is 3.3 cm., the maximum peripheral velocity obtained 3×10^4 cm/sec. Although this is much less than the 7×10^4 cm/sec reported by Moon (2), it was felt that valuable experience could be gained from the experiments with this very simple device. In view of the small velocities available, the centrifuge method was only applied to Pr^{141} and Tl^{203} and not to the higher energy transitions in Hg^{198} and Hg^{202}. No attempt was made with the 209 kev transition in Hg^{199}. This transition occurs only in a small percentage of the Au^{199} disintegrations. Moreover, the presence of the strong 159 kev radiation necessitates prediscrimination by absorption. A source sufficiently strong for the centrifuge experiment presented too large a radiation hazard.

The source material, contained in a minute stainless steel test tube, is inserted in a hole close to the periphery of the rotor, the average effective radius being 1.40 cm. Another test tube of comparable mass is inserted into a hole diagonally opposed in order to balance the rotor.

To select the gamma rays emitted in the forward direction, Moon and co-workers (2) had designed an elaborate baffle system which had the advantage of utilizing a large solid angle but the disadvantage of rendering the analysis of the data cumbersome and uncertain. In our

experiment the gamma rays emitted tangentially are selected by using a point source on the rotor, a small disc-shaped target and a gating arrangement which switches the counter on every time the point source is in the proper (tangential) position relative to the scatterer. The gating is done via a light beam striking the cylindrical periphery of the rotor. The greater portion of the periphery is blackened with India ink and does not reflect the beam. A region corresponding to the desired angular opening of the gamma-ray cone is not covered with ink and the polished aluminum surface reflects the beam onto the cathode

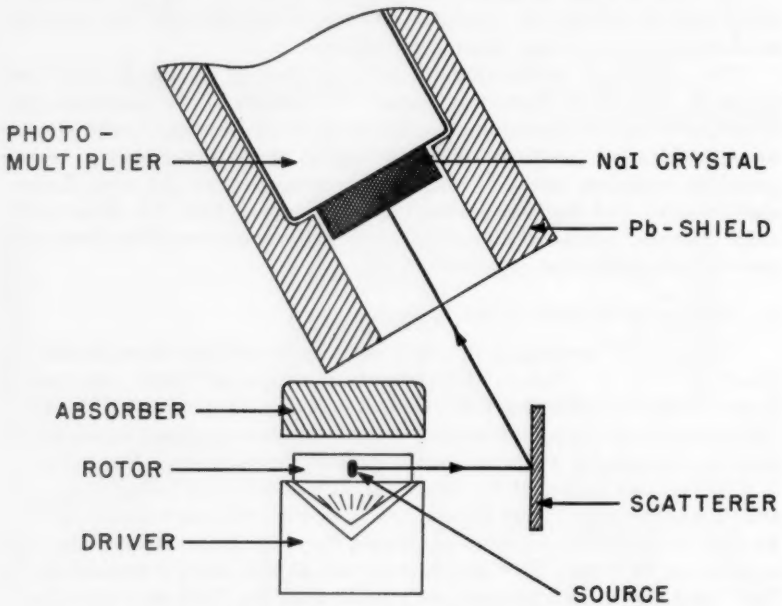

FIG. 2. Arrangement used for the centrifuge experiments. The gating facilities are omitted. The NaI crystal was surrounded by $\frac{1}{32}$ in. of Cd.

of an RCA 931-A photomultiplier tube. As long as the signal lasts, that is, as long as the polished portion of the periphery is struck by the light beam, the gate is open and the output of the scintillation spectrometer is connected to a scaler registering the number of counts due to elastically scattered quanta. Another scaler records the number of gating pulses and thus measures the number of revolutions of the rotor.

By properly adjusting the position of the light beam, the middle of the counting period is made to coincide with the exact tangential position.

The gamma ray detection system and the shielding precautions are

identical with the ones already discussed in connection with the heating experiments. The use of matched scatterers—in this case matched at zero velocity of the source—was also taken over from the thermal experiments.

RESULTS AND DISCUSSION

Praseodymium 141

The disintegration scheme (8, 9) of 33-day Ce^{141} is very simple (Fig. 3). The K-conversion coefficient (10) $\alpha_K = 0.46 \pm 0.02$ characterizes the 145 kev transition as $M1$ or $E2$; the K/L ratio of ~ 5.5 indicates that the radiation is predominantly $M1$.

On the basis of the single particle lifetime formulae (11), one expects a lifetime of $\sim 10^{-11}$ sec. for an $M1$ transition of 145 kev energy. This value can be considered to be a lower limit for the actual mean life,

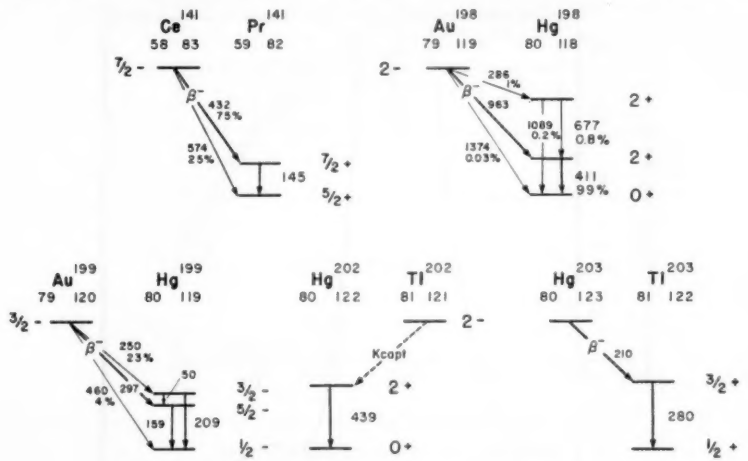

FIG. 3. Disintegration schemes of the isotopes investigated.

especially for an $M1$ transition involving a change of two units of orbital angular momentum ($g_{7/2} \rightarrow d_{5/2}$). An upper limit of 2.9×10^{-9} sec. had been established (12) for the mean life of the 145 kev level of Pr^{141} with the delayed coincidence method. With a total internal conversion coefficient of 0.55 this corresponds to a gamma-ray mean life τ_γ of 4.5×10^{-9} sec.

If the mean life of the transition is close to the single particle estimate, one expects a large resonance fluorescence effect, that is, an effect exceeding the total non-resonant elastic scattering. If, on the other hand, the mean life is close to the upper limit established by electronics, the resonance effect will be barely detectable in spite of the favorable abundance (100 per cent) of the responsible isotope Pr^{141}.

Experiments with sources (13) of Ce^{141} which had been chemically separated from other fission products were unsuccessful because the samples contained excessive amounts of $Ce^{144} - Pr^{144}$. Satisfactory sources were finally produced by neutron bombardment of separated (14) Ce^{140} in the Low Intensity Testing Reactor (LITR) at Oak Ridge (15) and in the Materials Testing Reactor (MTR) at Idaho Falls.

Pr_6O_{11} of 99.8 per cent purity (16) was used as the specific scattering material while BaO served as comparison material of neighboring atomic number.

a. Thermal Method

Figure 4 depicts the pulse height distribution of the radiation of Ce^{141} after scattering from a praseodymium scatterer ($\frac{1}{2}$ lb. of Pr_6O_{11})

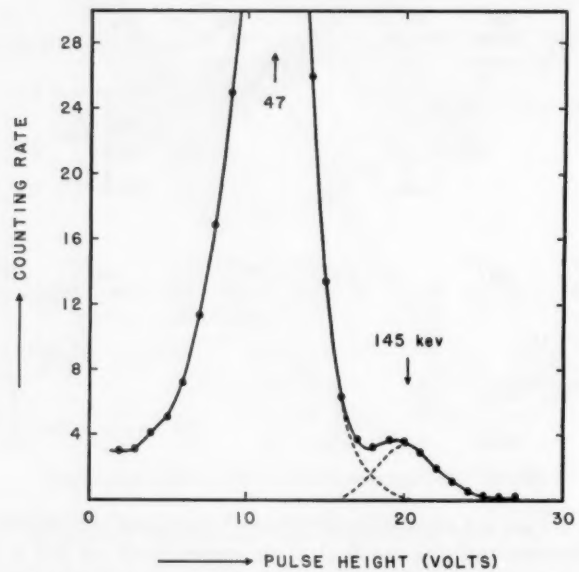

FIG. 4. Pulse height distribution of the radiation from Ce^{141} after scattering from Pr_6O_{11} ring scatterer. Geometry shown in Fig. 1 was used.

by an angle of 135°. The NaI crystal used as the detector was shielded by $\frac{1}{32}$ in. of Cd and $\frac{1}{64}$ in. of Pb. In order to reduce the contribution due to the tail of the Compton distribution, the channel of the single channel pulse height analyzer accepted only pulses falling into the upper half of the elastic peak.

For the 145 kev transition in Pr^{141} the recoil velocities due to the gamma emission are comparable to the thermal velocities at room

temperature. As a consequence, the 145 kev line emitted from a source of Ce^{141} and the absorption line of a praseodymium scatterer overlap to a considerable extent even when source and scatterer are at room temperature. While it is difficult to measure the resonance fluorescence cross section at room temperature directly, the change in the cross section upon heating or cooling of the source can be determined experimentally by observing the change in the counting rates of the two ring scatterers made of Pr_6O_{11} and BaO. With the help of Eq. 1, the measured changes in the cross section can be related to the natural width $\Gamma_{\gamma 0}$ of the gamma-ray transition or to the corresponding mean life

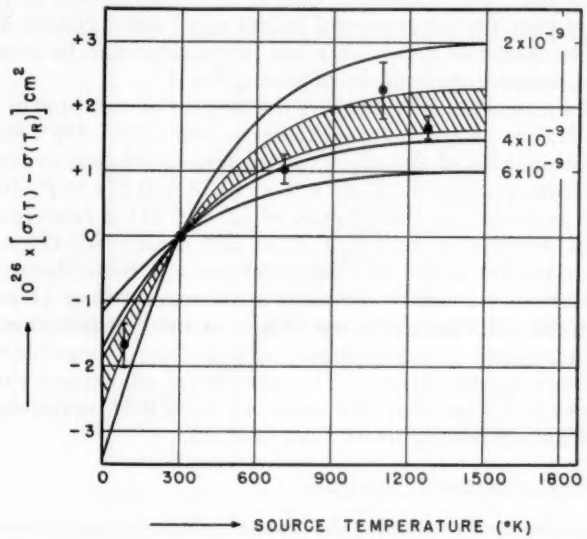

FIG. 5. Pr^{141}, thermal experiment.

Dependence of the resonance fluorescence effect on the temperature of the Ce^{141} source. The scatterer was kept at room temperature. The shaded area corresponds to $\tau_\gamma = (3.1 \pm 0.5) \times 10^{-9}$ sec.

$\tau_\gamma = \hbar/\Gamma_{\gamma 0}$. In using Eq. 1, it is assumed that the velocity distributions in source and scatterer are Maxwellian and that the total energy deficit due to the recoil energy losses is given by E_γ^2/Mc^2, where M is the mass corresponding to the atomic weight 141. The temperature dependence of the cross section for resonance fluorescence, expected on the basis of Eq. 1 for the 145 kev transition in Pr^{141}, is shown in Fig. 5 for different values of the mean life τ_γ. For source temperatures exceeding 1270° C., the resonance fluorescence effect decreases because at these elevated temperatures the emission line is spread out beyond the absorption line.

The experimental points are indicated in Fig. 5. The point at 1093°

abs. was measured at an average scattering angle of 148°, while the other points were obtained at an average scattering angle of 136°. The measured cross sections were corrected on the basis of an angular distribution $W(\theta) = 1 + 0.32\ P_2(\cos\theta)$. In judging the accuracy of the experimental points one has to remember that the largest difference measured corresponds to approximately 1.5 per cent of the total counting rate.

The best fit to the experimental points is obtained for a value $\tau_\gamma = (3.1 \pm 0.3) \times 10^{-9}$ sec. In view of the uncertainty in the angular distribution, a larger error is attributed to the final result of the measurements using the thermal method, that is, $\tau_\gamma = (3.1 \pm 0.5) \times 10^{-9}$ sec.

The fact that the experimental points agree satisfactorily with the calculated temperature dependence can be considered to be a confirmation of the assumptions made in obtaining Eq. 1.

An attempt was made to measure the angular distribution of the resonance radiation. Readings were taken at 105°, 120°, 135°, and 150°. Again, the smallness of the effect caused large statistical errors which make the least squares fit $W(\theta) = 1 + (0.32 \pm 0.17) \times P_2\ (\cos\theta)$ a poor guide as far as the mixing ratio of $E2$ and $M1$ is concerned. On the basis of the experimental K/L ratio, and considering the fact that Coulomb excitation of the 145 kev level has not been observed (**17**), the admixture of $E2$ can be assumed to be smaller than 15 per cent. For such small $E2$ admixtures only those angular distributions corresponding to negative values of the mixing ratio δ are compatible with the experimental range for A_2/A_0. The possible $E2$ admixtures vary from 0.16 per cent to 5.3 per cent, the value $A_2/A_0 = 0.32$ corresponding to $\delta = -0.14$ and an admixture of 2 per cent $E2$.

b. Mechanical Method (Centrifuge)

The experimental results for the resonance fluorescence cross section, obtained at different speeds of the rotor, are compared in Fig. 6 with the behavior expected on the basis of Eq. 1 for different values of the mean life τ_γ of the 145 kev transition in Pr^{141}. While in Section (*a*) the difference of the cross section at the temperature T and at room temperature was plotted, in this case the difference between the effects at a speed u and at zero speed is plotted.

Unfortunately the peripheral velocity necessary for complete overlap of emission line and absorption line could not be reached with our simple rotor. However, the results indicate reasonable agreement between experimental and theoretical shape. It would be desirable to repeat the experiment with an improved rotor and to determine with accuracy the location of the maximum of the curve relating cross section and source velocity.

The best fit to the centrifuge data is obtained with a mean life $\tau_\gamma = (2.9 \pm 0.5) \times 10^{-9}$ sec. This value is in good agreement with

the final result of the thermal experiment $\tau_\gamma = (3.1 \pm 0.5) \times 10^{-9}$ sec.

The combined result of the two resonance fluorescence experiments is $\tau_\gamma = (3.0 \pm 0.4) \times 10^{-9}$ sec.

Recently (18) the half-life of the 145 kev level in Pr^{141} has been measured with the delayed coincidence method as $(1.9 \pm 0.2) \times 10^{-9}$ sec. With $(1 + \alpha_T) = 0.55$, this leads to a mean life τ_γ of $(4.3 \mp 0.4) \times 10^{-9}$ sec. A smaller value of α_T would bring the two results into closer agreement.

The experimental value for the mean life τ_γ is approximately 300 times longer than the theoretical estimate (11) for a single particle $M1$

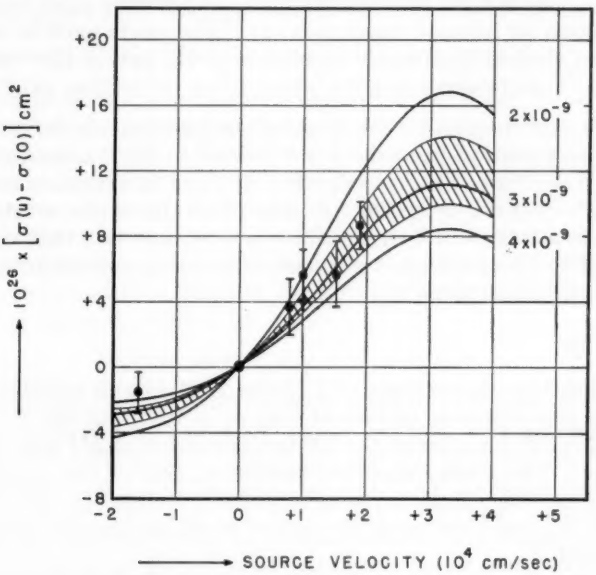

FIG. 6. Pr^{141}, centrifuge experiment.

Resonance fluorescence effect versus velocity of the Ce^{141} source relative to the scatterer. Positive sign applies to motion of scource towards scatterer. The shaded area corresponds to $\tau_\gamma = (2.9 \pm 0.5) \times 10^{-9}$ sec.

transition. The reduction in the transition probability is in line with the observations on other $M1$ transitions (19).

According to the angular distribution data, the $E2$ admixture is smaller than 6 per cent. The $E2$ transition probability is, therefore, of the order of the single particle $E2$ probability or smaller.

The long mean life of the 145 kev level in Pr^{141} poses some problem as far as the different behavior of Ce^{141} and Nd^{147} in nuclear alignment experiments (20) is concerned. While the mean lives of the 145 kev transition in Pr^{141} and the 92 kev transition in Pm^{147} are comparable, an alignment effect is observed with Ce^{141}, but not with the 92 kev radiation from Nd^{147}.

Mercury 198

The resonance fluorescence experiments involving the 411 kev excited state of Hg^{198} have been described in considerable detail elsewhere (21, 22). It suffices to quote the essential results:

(*a*) The angular distribution of the resonance radiation has the form $W(\theta) = 1 + (0.37 \pm 0.06)P_2(\cos\ \theta) + (1.07 \pm 0.08)P_4(\cos\ \theta)$ characteristic of an excited state with spin 2 and a ground state with spin 0.

(*b*) The mean life τ_γ of the 411 kev transition is $(3.15 \pm 0.3) \times 10^{-11}$ sec. This is 4 per cent shorter than our previous value because of the correction for internal conversion (5). The single particle estimate (11) for an electric quadrupole transition of 411 kev in Hg^{198} is 4.6×10^{-10} sec. The transition is thus fifteen times faster than predicted.

In our report (22) on the angular distribution of the resonance fluorescence radiation from the 411 kev level in Hg^{198} some indication for a small resonance fluorescence effect at room temperature was mentioned. Further investigation of this effect failed to establish its existence in a statistically significant way. It is certain that the effect is too small to affect the value of the mean life by an amount comparable to the quoted uncertainty.

Mercury 199

The disintegration scheme of 3.15-day Au^{199} is well established (23, 24). The K-conversion coefficient (24) $\alpha_K = 0.98$ and the K/L ratio (23, 24) of $\sim$5.5 characterize the 209 kev transition as $M1$ with little $E2$ admixture. The total conversion coefficient (24) of the transition is $\alpha_T = 1.22 \pm 0.25$. Taking place between p states, the 209 kev $M1$ transition is allowed as far as the change of orbital angular momentum is concerned.

Very recently, Graham *et al* (25) have reported a half-life of $(7 \pm 4) \times 10^{-11}$ sec. for the 209 kev level in Hg^{199}. The single particle mean life (11) for an $M1$ transition of 209 kev is $\sim 2.5 \times 10^{-12}$ sec.

The Au^{199} activity was chemically separated (26) from platinum targets which had been irradiated in the Oak Ridge Laboratory reactor. The activity was used in the form of elemental gold.

The 159 kev transition in Hg^{199} is several times more intense than the 209 kev transition. However, a lead shield of $\frac{1}{32}$ in. around the detector reduced the 159 kev gamma rays and the Compton scattered radiation sufficiently to make the elastic peak due to the 209 kev transition recognizable.

A small amount (<1 per cent) of Au^{198} was found to be present in all the Au^{199} sources. The presence of the 411 kev radiation is bothersome because it necessitates the use of a large absorber for the direct beam.

Moreover, the Compton scattered radiation due to the 411 kev gamma rays falls approximately in the region of the 209 kev elastic peak. In future experiments, efforts should be made to reduce the Au^{198} activity to an insignificant amount.

In view of the small resonance fluorescence effect, no attempt was made to measure the angular distribution of the resonance radiation or to check the temperature dependence of the effect. All measurements were restricted to 1000° C. and to room temperature. For a spin sequence $\frac{1}{2}-\frac{3}{2}-\frac{1}{2}$ and a mixture of dipole and quadrupole radiation, the highest term in the angular distribution is $\cos^2\theta$ or $P_2(\cos\theta)$. The data on Hg^{199} were taken at an average angle of 120°; that is at almost the angle (125°) for which the differential cross section is equal to $\frac{1}{4\pi}$ times the total cross section, independent of the coefficient of $\cos^2\theta$. Our ignorance concerning the angular distribution of the resonance radiation, therefore, does not affect the estimate of the lifetime appreciably.

As in the case of Pr^{141}, the 209 kev transition in Hg^{199} gives rise to a resonance fluorescence effect even at room temperature. Again, the difference of the cross sections at 1000° C. and at room temperature is related, through Eq. 1, to the mean life of the gamma transition. Two gamma-ray transitions deexcite the 209 kev level in Hg^{199}; the total width Γ of the level is given by

$$\Gamma = (1 + \alpha_0)\Gamma_{\gamma 0} + (1 + \alpha_1)\Gamma_{\gamma 1}$$

where the index 1 refers to the 50 kev transition. $(1 + \alpha_1)\Gamma_\gamma$ is estimated (**23, 24**) to be one-fifth of $(1 + \alpha_0)\Gamma_{\gamma 0}$, that is, $\Gamma = \frac{6}{5}(1 + \alpha_0)\Gamma_{\gamma 0} = 2.66\,\Gamma_{\gamma 0}$. With these values for the partial and total widths, the measured cross section difference $[\sigma(1300°) - \sigma(300°)] = 2.1 \times 10^{-25}$ cm² leads to a mean life τ_γ of $(1.2 \pm 0.4) \times 10^{-10}$ second. The standard deviation quoted reflects the large statistical uncertainties which are so typical for most of the thermal resonance fluorescence experiments. Using again the ratio $\Gamma/\Gamma_{\gamma 0} = 2.66$, Graham's (**25**) value for the mean life becomes $(2.7 \pm 1.6) \times 10^{-10}$ seconds, in fair agreement with the result from the resonance fluorescence experiment.

Considerable improvement is possible in both types of experiments and in the knowledge of the total conversion and the branching.

On the basis of this presently available information, the 209 kev $M1$ transition in Hg^{199} is approximately 50 times slower than predicted on the basis of the single particle picture (**11**). The successful competition of the 50 kev transition, which presumably involves a change of two units of orbital angular momentum, shows that "l-forbiddenness" does not necessarily cause a large reduction of the transition probability. In the case of Hg^{199} (119 neutrons) which is considerably removed from the closed neutron shell $N = 126$, mixing of configurations might account for the weakening of the l-forbiddenness (**27**).

*Mercury 202***

12.3-day (28) Tl^{202} decays by electron capture (29) to the 439 kev excited state of Hg^{202} (29.8 per cent abundant). On the basis of measured K/L and $(L_I + L_{II})/L_{III}$ ratios and of the systematics (30) of the first excited states of even-even nuclei, this level was assigned (29) spin 2, even parity.

The Tl^{202} activity was produced by bombarding HgS with 150 μa-hr. of 15 Mev deuterons in the MIT cyclotron (31). A metal source was prepared by electroplating thallium out of an ammonia solution (pH = 10) to which several hundred milligrams of hydroxylamine hydrochloride had been added. With a current density of 50 ma/cm^2 at the platinum electrodes, more than 95 per cent of the activity was plated out in two hours (32).

The application of the thermal method to Tl^{202} posed a problem which had not been encountered with the substances discussed so far: Tl metal and the commonly available Tl compounds exhibit a considerable vapor pressure at 1000° C. This means that for part of the source, namely the gaseous fraction, the basic condition for the applicability of the thermal method is no longer fulfilled. The gaseous portion retains a memory of the neutrino recoil accompanying electron capture and the emitted gamma line no longer has the thermal shape. The actual shape of the line depends on the relative amounts of liquid and gaseous source material, on the transition energy of the electron capture transition, and on the particular molecular form of the vapor.

In order to avoid these complications, the least volatile form of thallium, metallic thallium, was used. Moreover, 50 mg. of inert thallium metal were added to the radioactive metal and the source was sealed into a quartz ampoule of 0.6 ml. volume. Under these circumstances 0.02 mg. of Tl will be in the vapor phase and ~50 mg. in the liquid phase when the ampoule is heated to 1000° C., that is only one part in 2500 of the activity will be in the gaseous phase. This type of source then represents a very good approximation to a "thermal" source.

The measurements necessary for the determination of τ_γ were carried out at an average scattering angle of 113° and at source temperatures of 802° C. and 1005° C. Using Eq. 1 and assuming a total conversion coefficient of 4×10^{-2}, the mean life fitting both runs was found to be $(3.4 \pm 0.7) \times 10^{-11}$ second. This is very closely the same as the $\tau_\gamma = (3.15 \pm 0.3) \times 10^{-11}$ second, measured for the 411 kev transition in Hg^{198}. Although the uncertainties in the τ_γ's are still rather large, the experiments indicate that the 439 kev transition in Hg^{202} is not faster than the 411 kev transition in spite of the higher energy. In view of the general behavior of fast $E2$ transitions (33) this result is not surprising, because Hg^{202} with 122 neutrons is closer to the $N = 126$ shell, the col-

** A short report on these experiments appeared in *Phys. Rev.*, Vol. 98, p. 200 (1955).

lective motion therefore reduced, the energy of the first excited state increased and the transition probability closer to the single particle value.

Prior to the lifetime experiments, the angular distribution of the resonance radiation from the 439 kev level in Hg^{202} was measured. It was found to agree within the experimental uncertainties with the distribution $W(\theta) = 1 + 0.357\ P_2(\cos\theta) + 1.143\ P_4\ (\cos\theta)$ expected for a spin sequence 0–2–0.

The study of the angular distribution was carried out using a gaseous source of Tl I. Due to the neutrino recoil, the overlap of the emitted line and the absorption line is considerably larger for such a source than it is for a thermal source at 1000° C. For the angular distribution study, the lack of our knowledge of the exact shape of the emitted line is irrelevant and the increased resonance fluorescence effect renders the study less tedious. It is hoped that ultimately an experiment with a gaseous source of thallium metal will be possible and will allow the determination of the electron capture transition energy.

Thallium 203

46-day Hg^{203} as well as 52-hr. Pb^{203} decay to Tl^{203} (29.5 per cent abundant). For the present investigation Hg^{203} was used exclusively because of the simplicity of its disintegration scheme (Fig. 3) and the convenient half-life. For the evaluation of the data a value $\alpha_T = 0.225 \pm 0.01$ (**34**) was used for the total conversion coefficient of the 280 kev transition.

The lifetime of the 280 kev gamma ray in Tl^{203} was of special interest, because this transition is clearly a mixture of $M1$ and $E2$ (**35**) the $M1$ to $E2$ ratio being approximately one to three. The question to be answered by the lifetime measurement was whether the large $E2$ component was due to an increased $E2$ transition probability or whether it was due to a radically reduced $M1$ probability. At the time these experiments were started, delayed coincidence experiments (**36**) had established that $\tau_\gamma < 7 \times 10^{-10}$ second. This was, however, not sufficient to decide the question raised above; on the other hand, such an upper limit made a resonance fluorescence experiment appear feasible.

For the study of Tl^{203}, the maximum peripheral speed obtainable with our simple rotor was even more inadequate than it had been for the case of Pr^{141}. The centrifuge experiments were therefore not continued beyond the preliminary stage in which it had been shown (**37**) that the mean life $\tau_\gamma = (7.3 \pm 3.3) \times 10^{-10}$ sec.,*** obtained with the mechanical method, agreed with the mean life measured with the thermal method.

For the thermal experiment, sources of processed Hg^{202} were obtained from Oak Ridge National Laboratory. Metallic mercury was plated

*** The internal conversion is taken into account, see Ref. 5.

out of the nitrate solutions onto silver foils and was then distilled into the quartz ampoules serving as the source containers. In order to obtain "thermal" sources, that is, sources in which thermal equilibrium was reached after the beta decay of Hg^{203} and before the gamma emission, high Hg pressures had to be used. It was found that the 0.6 ml. quartz ampoules withstood pressures of 600 lb/in^2 at temperatures of 1000° C. Under these conditions the large collision rate assured the loss of any memory of the beta-ray emission.

The preliminary results (**38**) on the mean life of the 280 kev transition in Tl^{203} were quoted with large errors because at that time conical scatterers had been used and had made the evaluation of the effective solid angles rather difficult. The measurements reported here were carried out with cylindrical ring scatterers made of metallic thallium and metallic lead (comparison scatterer).

The experiments with the high pressure Hg^{203} sources were performed at room temperature and at 1030° C. with scattering angles of 103°, 132°, and 150°. The angular distribution fitting the data has the form $W(\theta) = 1 + (0.63 \pm 0.4)P_2(\cos\theta)$. For the spin sequence $\frac{1}{2}$–$\frac{3}{2}$–$\frac{1}{2}$ no higher order Legendre polynomials have to be considered.

For the difference (σ_{av}(1303° abs.) − σ_{av}(300° abs.)) a value (3.6 ± 0.6) × 10^{-26} cm^2 was obtained. According to Eq. 1 this cross section difference is equal to 2.59 × 10^{-20} × $\Gamma_{\gamma 0}$, where $\Gamma_{\gamma 0}$ is measured in ev. The width $\Gamma_{\gamma 0}$ of the 280 kev transition is therefore (1.39 ± 0.23) × 10^{-6} ev; the corresponding mean life τ_γ = (4.7 ± 0.8) × 10^{-10} sec.

While this paper was being prepared for publication, several reports concerning the mean life of the 280 kev transition have come to our attention. The mean lives obtained from measurements of the cross section for Coulomb excitation (**39, 40**) depend on the assumption concerning the $M1/E2$ mixing ratio and are therefore somewhat more uncertain. Within the errors quoted they agree with our value.

A more direct comparison is possible with the results obtained with the delayed coincidence method. In this case the total conversion coefficient is the only factor that might affect the comparison. Using the value α_T quoted earlier, the following mean lives have been reported: (2.1 ± 0.6) × 10^{-10} second (**41**), (3.7 ± 1.2) × 10^{-10} second (**42**), and (4.4 ± 1.2) × 10^{-10} second (**43**). The agreement of the mean lives obtained with the two different methods is satisfactory if one considers the large scatter of the delayed coincidence results.

With an $M1/E2$ ratio of 1:3, the measured partial $M1$ lifetime $\tau_\gamma(M1)$ becomes about 2000 times longer than the single particle prediction (**11**). The transition in Tl^{203} is an odd proton transition between a $d_{3/2}$ and an $s_{1/2}$ level, that is, an "l-forbidden" transition. The fact that for the l-forbidden 50 kev transition in Hg^{199} the slowing down was small while it is large for the 280 kev transition in Tl^{203} might be attributed to the greater purity of the single particle states in Tl^{203}

which is just one proton short of a closed shell ($Z = 81$). The partial experimental $E2$ lifetime $\tau_\gamma(E2) = 6.3 \times 10^{-10}$ second is approximately four times shorter than the single particle estimate (11). This is reasonable for a proton number of 81, that is, for a nucleus approaching a closed shell.

The lifetime measurement shows that the reason for the large $E2$ admixture in the 280 kev transition in Tl^{203} is mainly a strong reduction of the $M1$ transition probability.

SUMMARY

The feasibility of lifetime measurements with the "thermal resonance fluorescence method" has been demonstrated. Where a comparison is possible, the lifetimes measured with this method agree with those obtained with the delayed coincidence technique. For the region from 10^{-9} to 10^{-10} sec. the two methods are at present capable of comparable accuracy.

The measured mean lives of electric quadrupole transitions were found to be about as short or shorter than the single particle estimate. The magnetic dipole transition probabilities, on the other hand, are strongly reduced. For the "l-forbidden" magnetic dipole transitions there is some indication that the purity of the states is the main factor governing the reduction of the transition probabilities.

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NUCLEAR ENERGY NEWS

INDUSTRY PARTICIPATION IN NUCLEAR ENERGY

The Atomic Energy Commission during the latter part of 1955 continued its encouragement of participation by industry in the development of nuclear energy in several different ways.

It announced that The Babcock and Wilcox Company of New York has been awarded the first lump sum contract for the fabrication of reactor fuel elements in a privately-owned facility. The company will fabricate 325 fuel assemblies for the AEC's Materials Testing Reactor. Previously these fuel elements had been fabricated at the Oak Ridge National Laboratory.

A similar move was a request to private industry to submit proposals to supply reactor grade beryllium metal. These requirements are now met from the production of a government-owned plant at Luckey, Ohio, operated for the AEC by the Brush Beryllium Company. In addition to the metal required by the AEC, quantities of beryllium may be required for privately-financed projects. The AEC does not intend to provide beryllium for such projects.

Another way that the AEC is assisting industry to become acquainted with its needs is through seminars at its national laboratories. One was held at the National Reactor Testing Station in Idaho on November 1 and 2. This one dealt with the development by the Argonne National Laboratory of the Boiling Water Reactor and the Fast Breeder Reactor, which are part of the Commission's Power Reactor Development Program. Another seminar in this series designed to inform industry was held at the Brookhaven National Laboratory on November 21 and 22. It dealt with the Liquid Metal Fuel Reactor.

The Commission has solicited proposals for the production of refined uranium salts in privately owned and operated facilities. This action represents another step in the Commission's efforts to expand the scope of private participation in the uranium industry. It is interested in receiving proposals from qualified firms to process, over a 5-year period, uranium ores or concentrates to either uranium tetrafluoride, or uranium hexafluoride. Proposals will be accepted until October 1, 1956 for deliveries to begin April 1, 1959.

ARGONNE NUCLEAR SCHOOL

The first session of the School of Nuclear Science and Engineering at the Argonne National Laboratory near Chicago (see this JOURNAL,

Vol. 259, p. 442) was so successful that a second session was started November 7, 1955. Among the 66 students, 45 came from 21 foreign nations. They will receive a seven-month course of instruction in unclassified technology concerning nuclear reactors and related subjects dealing with peaceful applications of nuclear energy.

A special Summer Institute on Nuclear Engineering of two-months' duration is to be given in the summer of 1956 for 60 engineering college faculty members. This course is sponsored jointly by the American Society for Engineering Education and the National Science Foundation. The former will arrange for the selection of the students and their housing. The latter will provide cost-of-living stipends at about $600 each.

The purpose of the Institute is to broaden the educational base of the nation in atomic energy by equipping more college faculty members to teach students of nuclear sciences. Courses will be given in nuclear physics, nuclear engineering, metallurgy, instrumentation and other subjects. It will be the policy of the institute to accept from a single university or college two to four faculty members representing various engineering fields. This policy will permit spreading nuclear technology into the existing disciplines and make possible a better integrated program of nuclear training in the schools.

MEDICAL REACTOR AT BROOKHAVEN

A medical research center, including a nuclear reactor designed specifically for medical research and treatment, will be constructed at Brookhaven National Laboratory. Scheduled for completion in two years at a cost of $6,000,000 (exclusive of design and engineering), the new facility will house a nuclear reactor, a research hospital, an industrial medicine branch, and research divisions in medical physics, pathology, microbiology, biochemistry, physiology and clinical chemistry.

In the past few years, as the need for more adequate buildings to house the medical activities became apparent, preliminary designs were drawn up by members of the Brookhaven Architectural Planning Department, in collaboration with the medical staff. Innovations developed as a result of these early studies will be reflected not only in the reactor but also in the hospital and research buildings. An architect-engineering contract for design and construction supervision of the hospital, the laboratory and the reactor building has been awarded the firm Eggers and Higgins, New York City, by the Atomic Energy Commission. Upon completion of the plans and specifications, competitive bids will be invited, and the construction contract awarded on a lump-sum basis.

The medical reactor at Brookhaven will be one of the first two in the United States. In July 1955 the Commission announced that the

University of California had filed license applications with the Commission for construction and operation of a medical reactor on the campus of the University of California at Los Angeles (see this JOURNAL, Vol. 260, p. 314). When design specifications for the medical reactor are completed by Brookhaven scientists and engineers, proposals will be sought from firms in the equipment manufacturing field for fabrication of the reactor and its associated control equipment.

Medical research and treatment with neutrons have been conducted at Brookhaven since 1951 by utilizing the general purpose research reactor already in operation there. Treatment of patients at this reactor, however, requires that other work cease during the medical run, interrupting the research programs of other Laboratory departments. The new reactor, designed specifically for medical utilization, will make available a source of neutrons for experimental work on brain cancer, as well as a number of special short-lived radioisotopes, permitting a much wider range of medical investigation than now under way.

SODIUM-GRAPHITE POWER REACTOR

One of the proposals received by the Atomic Energy Commission under the Power Demonstration Reactor Program was from the Consumers Public Power District of Nebraska (see this JOURNAL, Vol. 259, pp. 240 and 531). It described a sodium-cooled, graphite-moderated nuclear power plant with a capacity of 75,000 net electrical kilowatts.

The original proposal was not acceptable to the Commission because of the financial arrangements suggested; but a revised proposal was approved in principle late in October 1955. The proposed reactor is to be designed by the Atomic International Division of North American Aviation, Inc. That company already has designed a pilot reactor of the same type for operation in 1956 at Santa Susana, near Los Angeles, California, under contract with the Commission (see this JOURNAL, Vol. 260, p. 131). The full-scale Nebraska plant is to be completed in 1959.

ARMY PACKAGE POWER REACTOR

Construction work on the Army Package Power Reactor project (APPR) was started in October 1955 at the Engineering Research and Development Laboratories, Fort Belvior, Virginia. Award of the contract for the APPR to Alco Products, Inc. had been announced in December 1954 (see this JOURNAL, Vol. 259, p. 239). Since that date, Alco has been engaged in the detailed design of the plant which will generate about 2000 kilowatts of electricity for use in normal post operations at Fort Belvior. It has initiated manufacture and procure-

ment of equipment requiring long lead-times and plans to place the APPR in operation by early 1957.

NUCLEAR POWER PLANT FOR BELGIUM

Belgian private enterprise will install an atomic power plant to provide electrical energy during the Brussels World's Fair in 1958. The plant will be the first completely privately financed atomic-electric power plant to go into operation anywhere in the world. It will be built within a few miles of the center of Brussels. Work on the project is already under way in Belgium and the United States.

The electric generator will have a capacity of 11,500 kilowatts, using power from a Westinghouse pressurized water reactor. Fuel elements for the unit will be fabricated by Westinghouse from special material furnished by the U. S. Atomic Energy Commission under a separate agreement reached between representatives of the AEC and Belgium. This agreement was outlined in the Belgian Government's bilateral agreement with the United States Government, signed in 1955.

The plant will consist of a primary and a secondary system. The primary system, comprising a reactor, steam generators, pumps, and high pressure auxiliary equipment, will be enclosed in a large vapor container. The container will prevent release of radioactivity in the very remote possibility of a leak in the primary system. The secondary system, which will utilize the heat of the reactor, will consist of conventional steam turbine electric equipment located outside and independent of the vapor container.

When necessary to change fuel elements, they will be removed from the reactor and handled under water, the water providing both cooling and shielding during refueling operations. Liquid waste-disposal facilities will be provided to collect and store wastes that may become contaminated.

The plant will be built under the responsibility of the Syndicat d'Etude de l'Energie Nucleaire, which will also operate it. This company is an organization of Belgian utilities and manufacturers formed recently to develop industrial uses of nuclear energy in Belgium.

Westinghouse will manufacture all equipment for the primary system. Apparatus for the secondary system and various auxiliary equipment will be produced by Westinghouse and by Belgian manufacturers. Civil engineering work will be performed entirely by the Belgians. Gibbs and Hill, Inc., New York, has been retained by Westinghouse to assist on over-all plant engineering.

In addition to the atomic power plant itself, Westinghouse will furnish the Belgian group with the services of its own engineers and scientists to insure that the plant is placed in proper operation. The company will also provide training facilities in this country for operating personnel of the Belgian concern.

AEC PHYSICAL RESEARCH CONTRACTS

Award of seventy-five unclassified physical research contracts with universities and private research institutions was announced by the U. S. Atomic Energy Commission during October and November. Eighteen were new contracts, and the remainder were renewals of contracts which have been in force.

The contracts, which generally were for a term of one year, were let as part of the AEC's continuing policy of utilizing private research laboratories in conducting research related to atomic energy. They supplement the group announced earlier in the year (see this JOURNAL, Vol. 260, p. 133).

NEW AEC DIVISION OF INTERNATIONAL AFFAIRS

The Atomic Energy Commission announced on December 13, 1955 the establishment of a Division of International Affairs and the appointment of John A. Hall, as the Division's first director. Mr. Hall, who has been with the AEC since 1948, previously headed the Office of International Affairs which was absorbed in the new division.

Working in close cooperation with the State Department and other government agencies, the new unit is charged with the Commission's functions in connection with: (*a*) the bilateral agreements for cooperation relating to the peaceful applications of atomic energy; (*b*) the proposed International Atomic Energy Agency; (*c*) other matters of interest to the AEC before the United Nations such as proposals relating to disarmament; and (*d*) maintaining liaison with the State Department and foreign officials in connection with atomic energy matters.

STATE ADVISORY GROUP ON HEALTH AND SAFETY

The Atomic Energy Commission announced on November 25, 1955, establishment of a 12-member Advisory Committee of State Officials to consult with the Commission on regulations concerning health and safety aspects of private atomic energy activities. The committee members represent state agencies such as health, labor, public utility and legal departments. Some are from states already doing work in radiation protection.

Decision to establish the advisory group is an outgrowth of a meeting of state representatives in Washington last July with the AEC to discuss proposed regulations on radiation protection being formulated for AEC licensees (see this JOURNAL, Vol. 260, p. 317).

The AEC expects that cooperation with the states should help in attaining uniformity in regulations. Some states have already issued, or are about to issue, codes and regulations on radiation protection; others are doing preliminary work. Working through the advisory committee the Commission will keep informed of the needs of the states and will be better able to help states requesting technical guidance.

In general, the arrangement will provide for exchange of information which will be of aid to the Commission in discharging its regulatory responsibilities and to the states in keeping themselves informed of the activities of the Commission.

AEC ACCESS PERMITS

The AEC continues to issue Access Permits which entitle the holders, after security clearance, to use Restricted Data in the civilian atomic energy industry (see this JOURNAL, Vol. 260, p. 129). Ninety-seven were issued in October and sixty-six in November 1955. The total of Access Permits issued since the program began in late April was 543 by the end of November.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS

A CARDIOGRAPHIC JERKMETER

The National Bureau of Standards has devised a barium titanate jerkmeter for studying the action of the human heart. The instrument is essentially a piezoelectric accelerometer with an output that is electrically differentiated. Unlike most instruments used in ballistocardiography, the Bureau's jerkmeter does not require a fixed reference point. Thus, it is inherently isolated from extraneous motions, such as building or operating-table vibrations. The device was designed and constructed by T. A. Perls and C. W. Kissinger of NBS under a program of basic instrumentation sponsored at the Bureau by the Department of Defense and the Atomic Energy Commission.

In general, a jerkmeter is a transducer which gives an electrical output proportional to jerk, the time derivative of acceleration. Jerk has been measured in connection with elevator and vehicle riding comfort as well as in various physiological studies.[1] The present development was undertaken to obtain measurements of the third time-derivative of the displacement of a reclining patient. The motion of interest is due to the inertial forces generated by the flow of blood and is therefore intimately related to the function (and malfunctions) of the heart. Developed as a research tool, the NBS jerkmeter is being used by the Civil Aeronautics Administration to study the correlation of jerk measurements with proper diagnosis of heart conditions.

Previous studies[2] have shown that the important frequencies for ballistocardiography extend from zero to about 20 cycles per second. Certain muscular tremors of higher frequency, apparently unrelated to heart action, make it necessary for jerkmeter-frequency response to drop off as rapidly as possible above 20 cps. In the NBS device, very fast drop-off is achieved by taking advantage of the mechanical resonance of the accelerometer and by properly selecting the time constant (RC) of the differentiator.

The jerkmeter makes use of a loaded cantilever to obtain the required low fundamental resonant frequency. In the present design the second mode of resonant oscillation is 11 times that of the fundamental. Thus the second mode does not interfere with the frequency-response drop-off in a range where normal recording equipment would have appreciable sensitivity.

[1] See, for example, D. P. ECKMAN, "Industrial Instrumentation," New York, John Wiley and Sons, 1950, p. 213.

[2] J. E. SMITH, M. D. AND R. ROSENBAUM, *Am. Heart J.*, Vol. 46, p. 799 (1953).

Electrical signals are obtained from a small barium-titanate sandwich-type element. The element is attached near the clamped end of the cantilever by means of three metal straps. In order to minimize the effect of the element's temperature sensitivity and to provide an adjustable viscous damping, the cantilever is enclosed in a container filled with a silicone fluid. The fluid was chosen on the basis of tests and theoretical considerations which determined the viscosity necessary for satisfactory damping. Temperature-dependency tests indicate that the jerkmeter sensitivity remains within 10 per cent of its zero-frequency value up to 17.5 cps. provided the temperature remains between 18° and 24° C.

The jerkmeter was calibrated under quasi-steady-state conditions by comparison with a commercial accelerometer previously calibrated by the "chatter" method.[3] Response of this accelerometer was made independent of frequency within 2 per cent, down to 1 cps., by means of a capacitive shunt and cathode follower. The two transducers were mounted back-to-back on the end of a long cantilever bar. The other end of the bar was clamped in a vise. By changing the free length of the bar, and by changing bars, a test-frequency range from 1 to 60 cps. was covered.

Over its "flat" frequency range the jerkmeter's sensitivity (voltage output per unit jerk) is the product of the accelerometer charge sensitivity and the load resistance. The low-frequency jerk sensitivity is thus independent of the capacitance of the circuit. This is an advantage since the input capacitances of amplifiers suitable for jerkmeter use are not always readily measured.

For use in ballistocardiography, the jerkmeter is attached to the subject's body by coupling means of known characteristics. It may, for example, be mounted on a wooden platform which rests on the shins of a reclining patient. For good mechanical contact, the shins may be wrapped with short sections of elastic bandage.

REFERENCE SAMPLES OF ISOTOPIC ABUNDANCE

Many laboratories throughout the world are engaged in mass spectrometer research on the natural abundance of isotopes of the various elements. Such research is invaluable in geology and geophysics for determining the age of minerals. It also provides information on the temperature and physical conditions of the earth when various minerals were formed. However, in performing this research each laboratory has adopted arbitrary standards of comparison. Because of this lack of common standards to which all measurements

[3] C. W. KISSINGER, Instr. Soc. of Am. Paper No. 54-40-1, September 1954, reprinted March 1955.

can be referred, an unnecessary uncertainty exists in available isotope abundance data.

For this reason, the National Bureau of Standards, at the request of the United States Geological Survey, has undertaken a program of preparing and distributing reference samples for use in research on natural abundance of isotopes. Sponsored by the Atomic Energy Commission, the program is being carried out by the NBS Mass Spectrometry Section, under F. L. Mohler.

Samples will be available on an international basis and will consist of elements and compounds in forms suitable for mass spectrometer analysis. As a part of the program, the Bureau is determining the suitability of new chemical compounds for isotope measurements and is developing convenient preparation techniques. The Bureau also will serve as an international clearing house for data on the natural abundance ratios for these samples. Accumulated data on each element will be distributed with every sample sent out.

It will now be possible, for the first time, for all laboratories doing research on a particular element to be working with the same material. It is expected that use of the bank and compilation of different laboratories' results will tend to minimize the uncertainty in present-day measurements. This will lead to increasingly accurate and reliable values for the isotopic abundances of elements issued as reference samples.

As a preliminary step, a questionnaire was sent to a number of laboratories in the United States and abroad which specialize in isotope abundance research. They were asked to state the elements they were interested in, what chemical form they preferred, and whether they would cooperate in making analyses.

Response to the questionnaire indicated that there is interest in nearly all of the polyisotopic elements, particularly lead and the light elements. There were also requests for standards of deuterium oxide and deuterium. The various laboratories are equipped to make measurements by one or more of three different techniques. Some are prepared to measure gases, others compounds which are evaporated from a furnace, and others compounds which are evaporated from a heated filament as ions. Lead can be analyzed by all three methods as lead tetramethyl, lead iodide, and lead oxide or sulfide respectively. The alkali and alkali earth metals are commonly analyzed by thermionic emission.

At the present time 25 different chemical elements are available in 30 different compounds, and the list of elements and compounds is continually increasing. Small samples suitable only for mass spectrometer analyses are sealed in glass tubes for distribution. Gases and volatile liquids are in internal break-seal tubes. Mass spectrometer and spectroscopic analyses confirm that the materials are of suitable

purity for the purpose. Solid samples are carefully ground and mixed to assure homogeneity.

Most of the reference samples have been obtained from commercial sources, but in a few instances the Geological Survey has supplied natural minerals. The lead is from galena mined in Ivigtut, Greenland, the limestone is from a quarry in Bavaria, and the sulfur is from a sulfur dome in Texas. The sulfur reference samples are supplied both as native sulfur and as SO_2, and samples of the air used to make the SO_2 are available. This is desirable because isotopes of the SO_2 ion are commonly measured, and oxygen as well as sulfur contribute to the isotope pattern.

Other samples include water, hydrogen made from this water, deuterium oxide (heavy water) and deuterium gas derived from it, rare gases, alkali and alkali earth carbonates or salts, boron trifluoride, silicon tetrafluoride, compounds of copper, silver, and cadmium. There is also a small amount of pure mercury which was prepared as a density standard by the National Physical Laboratory in England.

Samples are now being distributed to various laboratories that have offered to collaborate in the analyses. Results of these analyses will be compiled and distributed to all laboratories that use the samples. Subsequently the samples will be sold for a nominal fee, and all users will be asked to report their measurements.

THE FRANKLIN INSTITUTE

MINUTES OF THE STATED MEETING

December 21, 1955

The Stated Monthly Meeting of The Franklin Institute was held on December 21, 1955, in the Lecture Hall. S. Wyman Rolph, President, called the meeting to order at 8:15 P.M. Approximately 150 members and guests were in attendance.

The President stated that the Minutes of the October Stated Meeting were printed in the November JOURNAL and Minutes of the November Stated Meeting in the December JOURNAL. There being no corrections, changes or additions to either, they were approved as submitted.

The Secretary reported that the following nominations for election to the Board of Managers had been made in conformity with Article IV, Section 5, of the By-Laws:

A. Felix du Pont, Jr.	Lionel F. Levy
J. G. R. Heckscher	Charles Penrose
Clarence L. Jordan	R. G. Rincliffe
Ralph Kelly	Philip H. Ward, Jr.

The President then called for nominations from the floor. There being none, he declared the nominations closed. George S. Crampton, Joseph S. Hepburn, and Howard Stoertz were appointed Tellers by the President.

The Secretary stated that Arne Tiselius, of Uppsala, Sweden, Franklin Medalist for 1955, had been nominated by the Board of Managers for Honorary Membership in The Franklin Institute. In accordance with the provisions of the By-Laws, upon motion duly made and seconded, Professor Tiselius was unanimously elected to Honorary Membership.

The Secretary reported that elections to membership, recorded during November, resulted in a net gain in the following classes of membership:

Active	9
Associate	10
Student	3
Individuals with Library privileges under Company memberships	1

and a total membership of 7,053 as of November 30, 1955.

He read the names of those who had completed twenty-five consecutive years of membership in the Institute during 1955, recognized by Silver Cards of Membership. (These will be listed under the Membership Section of the March JOURNAL.)

The President then introduced the speaker of the evening, Dr. Charles E. Mandeville, Assistant Director of the Bartol Research Foundation of The Franklin Institute, whose talk on "Luminescence of Solids as Induced by Nuclear Particles" and interesting demonstrations were well received by the audience.

The meeting adjourned at 9:30 P.M. with a rising vote of thanks to Dr. Mandeville.

HENRY B. ALLEN
Secretary

MINUTES OF THE ANNUAL MEETING

Wednesday, January 18, 1956

The Annual Meeting of The Franklin Institute was held on Wednesday, January 18, 1956, in Franklin Hall. Both the meeting and the dinner which preceded it commemorated the 250th Anniversary of the birth of Benjamin Franklin. S. Wyman Rolph, President, called the meeting to order at 8:20 P.M. Approximately 280 members and guests were in attendance.

The President announced that because the January issue of the JOURNAL was devoted to papers on the "Panorama of Progress" in honor of Benjamin Franklin, Minutes of our December Stated Meeting would not be published until the February issue.

He then called for the report of the Tellers appointed in accordance with the By-Laws to count the votes for the eight Managers to be elected. George Crampton, Chairman, reported that 1082 ballots were received, of which 1055 were legal and 27 defective, and that the nominees received votes as follows:

A. Felix DuPont, Jr.	1054	Lionel F. Levy	1050
J. G. R. Heckscher	1053	Charles Penrose	1052
Clarence L. Jordan	1054	R. G. Rincliffe	1051
Ralph Kelly	1054	Philip H. Ward, Jr.	1053

The President declared that the above members were thereby elected Managers of the Institute for a term of three years. He thanked George Crampton, Joseph Hepburn, and Howard Stoertz for their services.

He also announced that at the afternoon meeting of the Board of Managers, James McGowan, Jr., was elected to fill a vacancy on the Board created by the resignation of Hiram Lukens, who has moved away from the City.

The President stated that the Annual Report of the Board of Managers will be presented at a meeting in the spring after receipt of the Auditor's report.

The Secretary reported that elections to membership, recorded during December, resulted in a net gain in the following classes of membership:

Associate	7
Student	33
Individuals with Library privileges under Company memberships	5

and a total membership at the end of 1955 of 7,094.

The President pointed out that when Dr. Allen came to the Institute as its top executive staff officer in October 1935, we had approximately 2,500 members, just about one-third of our current membership, and that during two decades of service Dr. Allen has given freely of himself—of his time, his energy, and, during our lean years in the 'thirties, even of his money. The President stated that tonight's was his last report at a Stated Meeting, for on January 25th he retires. He asked for a rising vote of thanks for Dr. Allen that would also express good wishes for many happy years of good health and leisure.

The meeting resumed with comments by the President on the 250th anniversary of Franklin's birth. He called upon C. L. Jordan, member of the Board of Managers of The Franklin Institute and Chairman of the 250th Anniversary Committee for the International Celebration of the Birth of Benjamin Franklin. On behalf of the Congress of the United States, Mr. Jordan presented the Franklin Commemorative Medal of the United States Congress to The Franklin Institute. The Medal was accepted by the President for Institute membership.

The President then stated that the highest award of the Institute, the Franklin Medal, is usually made at our Medal Day Ceremonies in October but was deferred until this meeting so it could be part of the special Franklin observance. He called upon N. E. Funk, Chairman of the Franklin Medal sub-committee of our Committee on Science and the Arts. Dr. Funk introduced Arne Tiselius, of Uppsala, Sweden, to whom the President presented the Franklin Medal and a certificate of Honorary Membership in The Franklin Institute. Professor Tiselius spoke briefly about Franklin's association with Sweden, Franklin having signed the first treaty of friendship and commerce between the newly-formed United States and a foreign country.

The President introduced the speaker of the evening—I. Bernard Cohen, one of this country's eminent Franklin scholars, editor of *ISIS*, and a member of the Department of the History of Science at Harvard University. Dr. Cohen spoke most interestingly on "Franklin and the Twentieth Century."

The meeting adjourned at 9:50 P.M.

(NOTE: The full proceedings, including Dr. Cohen's address, will be published in the March issue of the JOURNAL.)

HENRY B. ALLEN
Secretary

MEMBERSHIP

ACTIVE MEMBERS ELECTED BY THE BOARD OF MANAGERS
December 21, 1955

ACTIVE FAMILY

Richard Jenney
Robert L. Kerr
Henry W. Peterson

ACTIVE

Bess Barg
Raymond J. Bowley
Albert T. Breslow
Benjamin F. Bullock, III
John Walter Chambers
Arthur I. Coleman
G. H. Goodman
Turgut N. Hamdi
C. C. Hannum
Albert H. Hertz
Seymour Hochman
G. William Holland
Joseph P. Hollenbach
Paul J. Johnson
Philip C. Keidel
Carmen R. Marino
John S. McCoy
Allen C. Munster
Robert N. Noyce
Frank D. Prager
Joseph H. Reese
Clyde A. Roberts, Jr.
John V. Russell
Harry H. Schmidt, Sr.
Paul Seel
Stanley A. Simon
Daniel G. Smith
W. Warren Wilson

ACTIVE NON-RESIDENT

Frederick E. Bechtel
Jesse Ormondroyd

ACTIVE MEMBERS ELECTED BY THE BOARD OF MANAGERS
January 18, 1956

ACTIVE FAMILY

John E. Armstrong
Fred H. Dietsch
Walter E. Goodman, Jr.

ACTIVE

E. Bockmeyer
William N. Campbell
John Colocousis
J. Ignatius Daily
Joseph P. G. Davis
Edward DeLong
Felice J. DeMaria
Jerry P. Donovan
Mills A. Eure
Florence W. Forsyth
Harold G. Griffin
George R. Heap
Frank J. Hermann
Loren C. Hurd
George J. Lavin
P. J. Leaper
J. R. Ludwig
H. B. Martling
H. A. McGinnis
Edward Shippen Morris
Leon N. Neulen
Carl Ohnmeiss
A. E. Pearce
Boris W. Pozniak
F. Herbert Radey
William P. Scott
Raymond A. Weinmann

ACTIVE NON-RESIDENT

M. L. Moss

NECROLOGY

D. Webster Anders '51
Herman F. Ball '53
Wilfred Bancroft '34
William B. Bodine '42
Howard W. Elkinton '20
Edward J. Harley '44
George C. Klauder '45
Frank N. Kneas '30
John S. Krauss '42
Philipp Lenard '32
Horace P. Liversidge '10
Howard A. Loeb '36
Thomas C. McBride '97
James McElgin '48
H. William Overman '51
Edwin A. Russell '50
Thomas A. Shallow '44
Robert J. Shoemaker '44
Roger W. Stamm '34
Sydney S. Stern '49
Alan Wood, 3rd '96

COMMITTEE ON SCIENCE AND THE ARTS

(Abstract of Proceedings of Stated Meeting held Wednesday, January 11, 1956.)

HALL OF THE COMMITTEE,
PHILADELPHIA, JANUARY 11, 1956.

MR. RALPH H. MCCLARREN in the Chair.

The following report was presented for final action:

No. 3296: Work of Floyd A. Firestone in Field of Ultrasonics.

This report recommended the award of an Edward Longstreth Medal to Floyd A. Firestone, of New York, New York, "For his invention and development of a practical industrial tool for the detection and measurement of the location and extent of defects in metal parts by ultrasonic means."

JOHN FRAZER,
Secretary to Committee.

LIBRARY

The Committee on Library desires to add to the collections any technical works that members may wish to contribute. Contributions will be gratefully acknowledged and placed in the Library. Duplicates received will be transferred to other libraries as gifts of the donor. 1047 items have been added the past two months.

Photostat service. Photostat prints of any material in the collections can be supplied on request.

The Library and reading room are open from 9 A.M. until 5 P.M. on Mondays, Tuesdays, Thursdays, Fridays, and Saturdays; and 2 P.M. until 10 P.M. on Wednesdays.

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JOURNAL OF THE FRANKLIN INSTITUTE

The following papers will appear in this JOURNAL within the next few months:

COHEN, I. BERNARD: Franklin and the Twentieth Century

SEJOURNET, JACQUES Y. P.: Origin of the Invention of Steel Extrusion by Glass Lubrication

BURKS, ARTHUR W. AND IRVING M. COPI: The Logical Design of an Idealized General-Purpose Computer

COHEN, HIRSH AND GEORGE HANDELMAN: Vibrations of a Rectangular Plate with Distributed Added Mass

GOLDWATER, J. H.: Effects of Electrolysis in the Thorium Oxide Emitter

EISENBUD, LEONARD: Time Dependent Formulation of the Collision Problem in Quantum Mechanics

JONES, E. E.: The Magnetostatic Force on Two Circular Cylindrical Conductors Carrying Uniform Steady Currents

CUNNINGHAM, W. J.: Nonlinear Oscillators with Constant Time Delay

TO MEMBERS AND THOSE WHO KNOW THE FRANKLIN INSTITUTE

All of us associated with The Franklin Institute are gratified by the support given by its benefactors in the past. Without their generosity our privately endowed Institute would have been unable to serve industry, the professions, and the public as it has and should.

There is still a continuing and pressing need of contributions and bequests —both for general and specific endowment, and of income to be judiciously used. Your response will be most earnestly appreciated.

Checks should be made payable to The Franklin Institute, and sent to The Franklin Institute, Benjamin Franklin Parkway at 20th Street, Philadelphia 3, Pennsylvania.

Where property is transferred, title should be in the name of The Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts.

We shall be glad to supply any additional information regarding gifts and memorials. Please write to the above address, attention of the Endowment Department.

NOTES FROM THE FRANKLIN INSTITUTE MUSEUM

A. C. CARLTON, DIRECTOR

THE SHIP IN AMERICA

"The sea is in his blood," we sometimes say of a man, and the saying is often true of a man whose life is spent far away from the margins of our coasts. The heritage seems to persist in many races, for many of the young men wearing naval uniform who visit the Marine Section of the Museum come from localities far inland.

Our country has a great maritime tradition. The Pilgrims, through poor navigation, found themselves upon New England's rock bound coasts instead of within reach of Virginia's fertile plantations. They were forced by sheer necessity into a seafaring life. The forests furnished an unlimited supply of ship building materials, the fishing and shipping trade offered the prospect of good profits. Favored by these conditions, American shipping became a threat to the parent country's sea-power. British acts to check the expansion encouraged smuggling and this, in turn, led to the development of ship's hulls to acquire that speed which became an American characteristic.

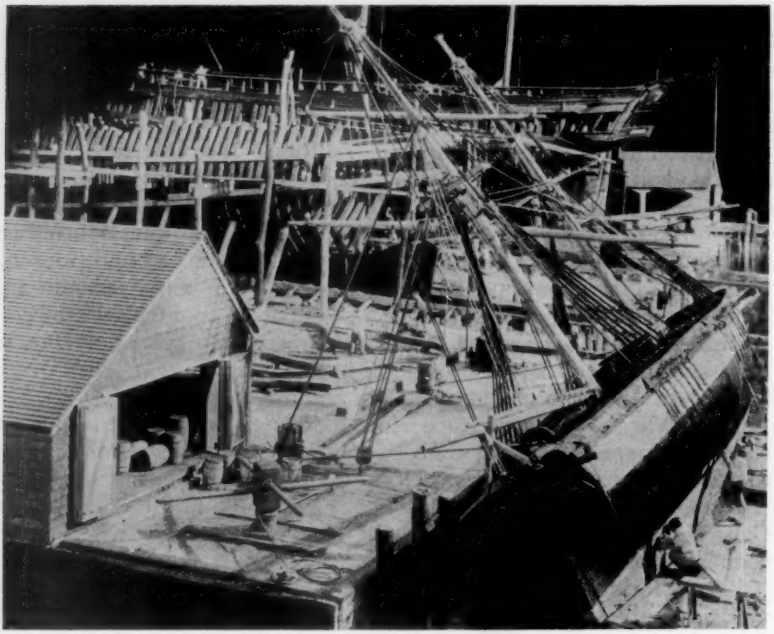
The War for Independence almost destroyed the American merchant marine, and the first concern of the founding fathers of the new republic was to restore the maritime industry, as a means of raising revenue and financing the war debt. Five of the first eleven Acts of Congress were designed to aid shipping. Under this wise policy, commerce prospered from the start.

The Marine Section of the Museum is concerned only with the maritime story of the United States. The series of models of the ships themselves have been chosen with special care for their fidelity of detail to illustrate the main developments in shipbuilding and ocean commerce. Many of them are used by artists desirous of obtaining accuracy in their pictures. In the great majority of cases the sails are omitted to permit an unobstructed view of the rigging.

By the way, did you ever think of the sails and rigging of a ship as its machinery? Joseph Conrad did, and he ought to know. "For machinery it is," he said, "doing its work in perfect silence and with a motionless grace, that seems to hide a capricious and not always governable power, taking nothing away from the material stores of the earth."

One of the most fascinating exhibits shows the building of a wooden ship. This shows all the functions required of the artisans. The visitor acquires a higher appreciation of their skills with only a few simple tools.

The display relating to the art and science of navigation is of special interest. Here one sees the primitive instruments used by the world's great navigators during the age of discovery. The modern sextant is one of the most beautiful instruments man has devised. The pilot house enables the visitor to see and to handle most of the latest navigation devices.



A brief story of steam ships is also told, from John Fitch's steamboat to one of the Navy's latest special vessels, a command ship. Few passengers ever get down into that mysterious area where the ship's power is developed, but visitors to the section may examine its mysteries at leisure in a handsome scale model provided by the Navy.

Although this department of the Museum has never failed to interest visitors, an effort is under way to make it more attractive and instructive.

NOTES FROM THE FRANKLIN INSTITUTE LABORATORIES FOR RESEARCH AND DEVELOPMENT

NICOL H. SMITH, DIRECTOR

COLUMN CURVES FOR TYPE 301 STAINLESS STEEL*

BY

E. W. HAMMER AND R. E. PETERSEN

Certain alloy steels of the stainless variety are important structural materials and are used in the railcar, truck tractor and aircraft industries because of their high strength-weight ratios. While there are a number of varieties of stainless, only type 301 has been considered in this program. Type 301 is of the 17–7 variety, 16.00 to 18.00 per cent chromium and 6.00 to 8.00 per cent nickel.

Type 301 stainless steel derives its strength from cold rolling and varies in tensile strength from 90,000 psi. in the annealed condition to 185,000 psi. in the full hard condition. The steel is commercially available in hardnesses of annealed, $\frac{1}{4}$, $\frac{1}{2}$ and full hard. Because of cold rolling the material becomes anisotropic (different properties in different direction) in all but the annealed condition. For 301, the material is strongest in the transverse direction in compression and weakest in the longitudinal direction in compression. Thus it is difficult to predict the physical behavior of type 301 stainless by standard methods of analysis. Aware of the increasing demand for this material and of the difficulty in predicting its physical behavior, the American Iron and Steel Institute initiated a research program at The Franklin Institute to prepare a design specification for the structural use of type 301 stainless steel. The first part of the program, the preparation of the column curves, has been completed.

For a material stressed below the proportional limit, the maximum apparent stress that a column with a stable cross-section can sustain is given by the Euler equation:

$$\frac{P}{A} = \frac{\pi^2 E}{\left(\frac{L}{\rho}\right)^2}.$$

However, for a material with no definite elastic limit (such as stainless steel) the above expression is not valid. Historically, F. Engesser

* This note is based upon research conducted by The Franklin Institute Laboratories for Research and Development under the sponsorship of the American Iron and Steel Institute.

proposed that the tangent modulus be used in place of Young's modulus for columns stressed beyond the proportional limit. Subsequently, Considere, Engesser, and later von Karman suggested that a reduced modulus (a combination of the initial and instantaneousness tangent moduli) be used. Critical column loads computed by the reduced modulus theory are somewhat higher than those computed by the tangent modulus theory.

In stainless steel design, it is claimed that the use of tangent modulus column curves for predicting allowable column loads usually gives loads lower than test values. Consequently, some designers have advocated that the reduced modulus be used for stainless steel because it gives higher values, which agree better with test results. Thus, in order to prepare column curves, it was necessary to decide which modulus to use in computing column curves. To resolve this question, an extensive test program was conducted. More than two hundred column specimens of annealed, $\frac{1}{4}$, $\frac{1}{2}$ and full-hard material, in slenderness ratios varying from 15 to 120, were tested.

The tests were conducted on 0.025, 0.050, and 0.072 thick, annealed material; on 0.020, 0.045, 0.062, 0.076 thick, $\frac{1}{4}$ hard; on 0.050, 0.025, and 0.075 thick, $\frac{1}{2}$ hard; and on 0.030, 0.045, 0.050, and 0.076 thick, full-hard material. For $\frac{1}{4}$, $\frac{1}{2}$ and full-hard material, specimens were made with the grain in both the longitudinal and transverse directions.

The specimens consisted of two hat sections shot-welded together to form a closed column. The width of flats was chosen so there would be no local instability. The ends of the specimens were ground parallel to one another within 0.0003 in. The cross section of a typical column specimen is shown in Fig. 1.

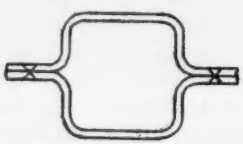


FIG. 1. Typical column cross section.

The tests were performed on a Baldwin-Tate-Emery Universal Testing Machine with a maximum loading range of 120,000 lb. Hardened steel (Rockwell C60) knife edges were used to obtain pin end conditions. The knife edges were calibrated against solid steel and aluminum rods and showed that pin-end conditions existed within $\pm 1\%$. See Fig. 2 for picture of test arrangement.

The results of the tests disclosed, for all practical purposes, that the test data for the $\frac{1}{4}$, $\frac{1}{2}$ and full-hard longitudinal specimens agreed with theoretical column curves based upon the reduced modulus in slenderness ratios less than 110; that for $\frac{1}{4}$, $\frac{1}{2}$ and full-hard transverse

specimens, the test data agreed with the theoretical column curves based on the tangent modulus; and that the agreement of the longitudinal test data with the reduced modulus column curves is due to the increased hardness—and therefore the increased load capacity—of the material in the rounds due to forming rather than to the behavior of the column according to the theory of the reduced modulus. (A "longitudinal" specimen means a specimen made with the grain parallel

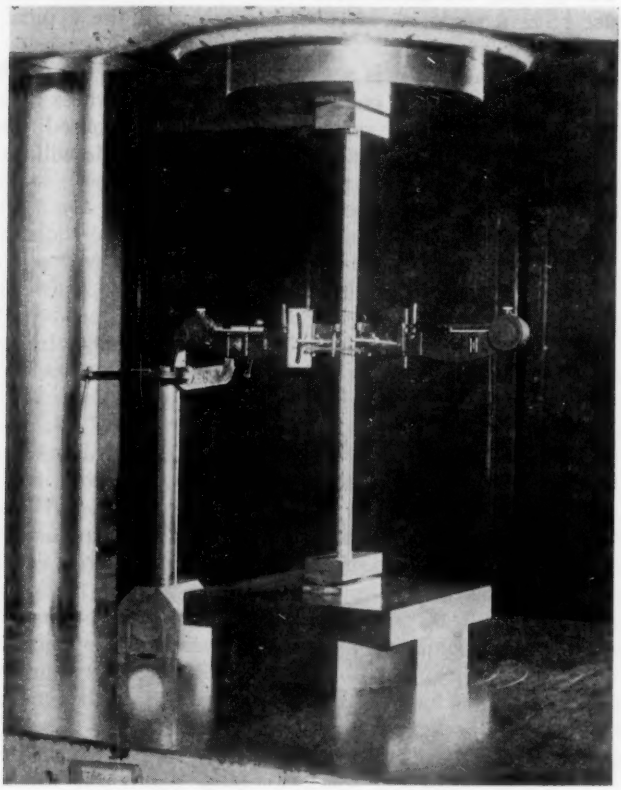


FIG. 2. Column test arrangement.

with the long axis of the column, and a "transverse" specimen means a specimen with the grain perpendicular to the long axis of the column.) In the slenderness ratios above 110 the reduced modulus column curves are slightly higher than the test data in the $\frac{1}{4}$ and $\frac{1}{2}$ hard material for both transverse and longitudinal grain.

Therefore, it is suggested that allowable column curves for $\frac{1}{4}$, $\frac{1}{2}$ and full-hard material be prepared based upon the reduced modulus for

the grain in the longitudinal direction and based upon the tangent modulus for the grain in the transverse direction. However, it must be remembered that this use of the reduced modulus is only a "gimmick" to account for the increased load capacity of a column due to forming the round. Typical stress-strain curves for the $\frac{1}{4}$, $\frac{1}{2}$ and full-hard material in both grain directions, upon which the design column curves are based, must also be given. The criterion for the use of the column curves will be that the stress-strain curve of the stainless steel to be used must have a slope equal to or greater than the typical stress-strain curves.

For annealed material it is suggested that the tangent modulus be used in preparing allowable column curves for slenderness ratios over 70. For lower slenderness ratios, column curves based upon the reduced modulus should be used, although actual loads will be appreciably greater than those predicted.

NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION

ELLICE McDONALD, M.D., FOUNDER
WILLIAM G. BATT, D.Sc., DIRECTOR

THE EOSIN STAINING METHOD FOR VIABLE CELLS TESTED ON X-RADIATED CELLS

BY

J. O. ELY, A. J. VIVOD AND WILLIAM G. BATT

The staining method of Schrek (1) for viable cells depends on the resistance of living cells to staining in order to differentiate between viable and non-viable cells. The method was checked by Schrek with cell suspensions of several tumors with satisfactory results.

In connection with X-radiation studies in this Laboratory, it has been found that the method, when applied to cells X-radiated *in vitro*, may indicate that there is no reduced viability although the cells do not grow and soon die.

Krebs 2 ascites tumor cells from 6-day implants in Swiss mice were obtained by washing the peritoneal fluid from the mice with glucosol (tyrode solution without the bicarbonate). The cell-containing ascitic fluid was centrifuged and the supernate was discarded. The sedimented tumor cells were then suspended in glucosol so that 500 ml. contained 272×10^6 tumor cells. In each experiment, one-half of this suspension of cells in glucosol was irradiated with 2000 r or 4000 r as described by Vivod (2). The other half, which was treated exactly the same except for the omission of irradiation, served as a control. Irradiation was done at room temperature on 20–40 ml. amounts in a large petri dish which was shaken during irradiation to keep the cells in suspension. After irradiation the fluid was centrifuged. The sedimented cells were suspended in 6 ml. of glucosol solution for injection into the mice. The inoculum per mouse contained 13.6×10^6 tumor cells. After inoculation was completed the eosin viability test was applied to the remaining portions of the cell suspensions. The time

TABLE I.—*Viable Cells as Indicated by the Eosin Staining Test Immediately after X-radiation.*

	Example No. 1 Viable Cells	Example No. 2 Viable Cells
	%	%
Control	84	77
2000 r	86	78
4000 r	87	82

required for preparation and irradiation of the cells was approximately half an hour and the eosin tests were made about three hours later.

The results of the viability test in two of the experiments, as examples, are shown in Table I. It may be seen that, according to the test, X-radiation had no effect on the number of viable cells.

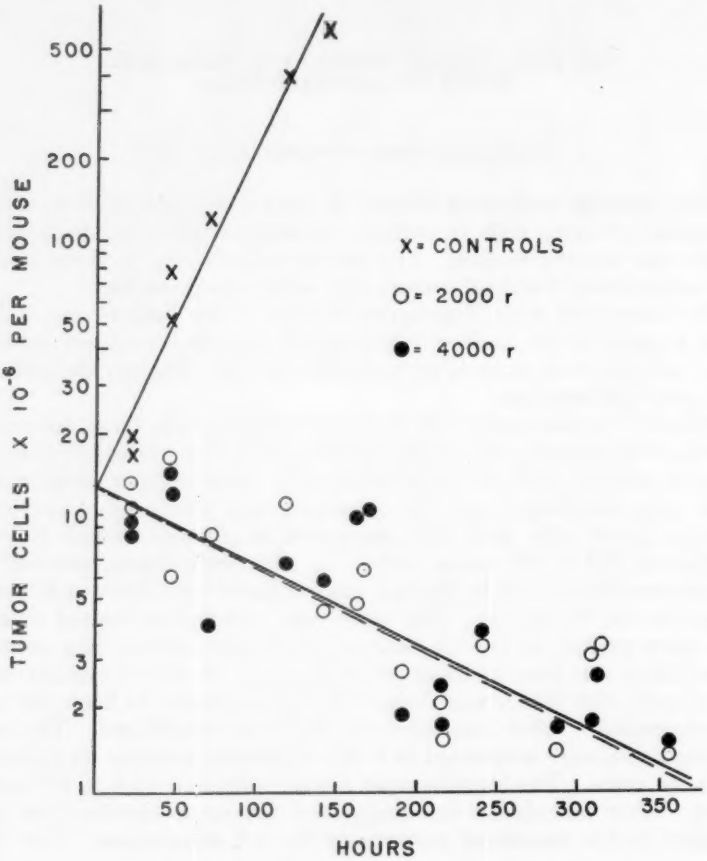


FIG. 1. Effect of X-radiation on growth of Krebs 2 ascites tumor cells.

Enumeration of the tumor cells from groups of 5 mice at intervals after inoculation of the mice, showed that the number of un-irradiated cells had increased rapidly whereas the number of irradiated cells declined progressively until all had died (Fig. 1).

Although the viability of the irradiated cells at the time of inoculation of the mice, as indicated by the test, was approximately the same

as that of the un-irradiated cells, the irradiated cells had been damaged so that they died later. X-radiation apparently injured the cells fatally without destroying cell impermeability to eosin. The test, made soon after irradiation, gave no indication of the damage that later caused death.

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(2) A. J. VIVOD, J. O. ELY AND WILLIAM G. BATT, JOUR. FRANKLIN INST., **260**, 543 (1955).

BOOK REVIEWS

THE ATOMIC NUCLEUS, by Robley D. Evans. 972 pages, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $17.00.

This book constitutes a comprehensive presentation of classical (low energy) nuclear physics. It is unique in that it may be regarded as both an elementary and advanced text. Both aspects are amply covered. The properties of whole nuclei are dealt with exhaustively. Stable nuclei, radioactive nuclei, and nuclei as the products of primary disintegrations and scattering are discussed with approximately equal emphasis. Parameters of the levels of the whole nucleus, spin, parity, energy, etc., are treated in clear detail.

Only occasionally are the results at bombarding energies greater than, say, 20 Mev drawn upon to illustrate the principles under discussion. Mesons are treated only briefly; positronium is mentioned and discussed qualitatively. The fact that these points are not emphasized is cited not as any disadvantage of the text but rather as a further indication that the prime aim of the book is to describe thoroughly the properties of the nucleus as a whole.

In order to increase the value of the book for experimental nuclear physicists, eight of the twenty-eight chapters deal with the interaction of charged particles and gamma-rays with nuclei and with extra-nuclear electrons.

It appears to have been a carefully planned policy to omit wherever possible detailed description of pure experimental technique. The names of some of the more important electronuclear machines are not given in the index of the book. It is the opinion of the reviewer that, in the light of the fact that such information is readily available in other texts, these omissions are completely justified. The space so saved has been devoted to three valuable chapters concerning statistical problems and the application of statistics to various devices employed in detection of nuclear particles, etc. A lengthy appendix in seven sections supplies mathematical studies of miscellaneous nuclear problems as well as various tables of nuclear data.

For the use of individuals who are interested in nuclear physics at practically any level of sophistication, particularly in the region of the binding energies or less, this book of 972 pages is recommended without reservation. C. E. MANDEVILLE

DIELECTRIC BEHAVIOR AND STRUCTURE, by Charles Phelps Smyth. 441 pages, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $9.00.

To most physical chemists, the name C. P. Smyth and the words "Dipole Moments" are almost synonymous. In almost thirty years of steady and fruitful research, he has come to be completely identified with the field of dipole moments and their interpretations. In an earlier book, "Dielectric Constant and Molecular Structure," which was published about twenty-five years ago, he succeeded in summarizing the entire field. Today, however, this would not be possible. The subject has grown much too large for one book or one man to cover completely. It was, therefore, inevitable for Professor Smyth in this present book to concentrate on certain areas, in which the coverage is very extensive, and to skim over others in order that they might at least be mentioned. In the latter areas, the book presents essentially an uncritical survey of the high points, but in the former, it is both a complete review of the experimental data and a detailed discussion of their interpretation in terms of the structure of the material. In both areas, it is a valuable source of references.

The book is divided into two main parts. In the first, the author considers the dielectric constant and loss in gases, solids, and liquids. A review of the theory is given, followed by a presentation of the data and their interpretation, and then by a chapter on the methods of measurement. In the second part, the general subject is the dipole moment and its relation to molecular

structure. The computational methods used to derive dipole moments from dielectric constant data for gases, solutions, and pure polar liquids are presented. A general description of how dipole moments may be used to deduce the molecular structure is given, and then the data for a wide variety of molecules are given and interpreted. A final chapter on electronic and atomic polarization completes the book.

As the author undoubtedly intended, judging from the remarks in the preface, the theoretical portions of the book offer only a survey of essential topics, with copious references. It is an unfortunate fact that in this field no really detailed and critical examination of the whole theory exists.

On the other hand, the sections of the book presenting dielectric constant data are particularly strong. This is naturally most true in those areas where Smyth and his students have made contributions. These include the determination of dipole moments of organic molecules, the dielectric properties of organic solids, both crystalline and glassy, and microwave data on organic liquids and solutions. Some of the important areas that are not thoroughly covered are those of inorganic solids, including ferroelectrics, polymers, and the microwave properties of gases. But perhaps this area does not belong in this book anyway, since, as the author says about gas measurements, "the microwave method becomes that of the spectroscopist."

Probably the most valuable portion of the book is the second section, which contains the discussion of dipole moments and how knowledge of them has increased our understanding of the structures of organic molecules. This section starts with the classic case in which the dipole moments of dichlorobenzenes were used to establish the validity of the Kekulé model of the benzene molecule. It carries through the whole range of aliphatic, alicyclic, and aromatic molecules, including rigid structures and those with internal rotation, and finishes with polypeptides and proteins.

In summary, this should certainly be a very valuable book. It should find its greatest usefulness as a general survey of the field of the dielectric properties of, primarily, organic material; as a reference book on the dielectric properties and dipole moments; and as an extensive discussion of dipole moments and molecular structure.

ALAN D. FRANKLIN

PRINCIPLES OF FARM MACHINERY, by Roy Bainer, R. A. Kepner and E. L. Barger. 571 pages, illustrations, 15 × 22 cm. New York, John Wiley & Sons, Inc., 1955. Price, $8.75.

This book is the fifth of a series of technical books on agricultural engineering subjects, previous ones being on tractors, farm buildings, soil and water conservation and processing of farm products. The series of books has been prepared for engineers and engineering students interested in farm problems. This book, like the others in the series, is not popular in nature and hence cannot be expected to have a wide market. Publication of the series was made possible by a grant from the Ferguson Foundation.

This new addition to the series fills an urgent need for a college textbook for students majoring in Agricultural Engineering as well as a reference book for practicing engineers. Until this time the only text books available on this subject have been semi-technical in nature and largely descriptive. This book brings together technical material which has been scattered thru various magazines and bulletins. As might be expected, the majority of the references are to articles in Agricultural Engineering, the journal of the American Society of Agricultural Engineers, but other sources of information are also included. Every chapter includes a list of references and many of the chapters are followed by problems useful in teaching.

Particularly gratifying is the fact that the book has considerable material on 3-point linkage, now widely used in different variations, for connecting implements to the tractor. 3-point linkage has been on the market since 1939 and thousands of units containing it are in use, yet this is the first book which has devoted appreciable space to explaining the principles involved. This is also the first book which has included material on the soil resistance which tillage tools encounter and the use of such material in the design and operation of the tools. The book should do much to correct several wrong ideas which have grown up around these two subjects.

Also commendable is the technical material given on seed cleaning and planting equipment, on hay and grain harvesting machines, on forage harvesters and on sprayers. It is true that all types of machines are not approached with the same degree of technical treatment but that is because less material of an engineering nature is available on some machines. For example, the grain thresher and the combined harvester-thresher have been developed largely as an art rather than as a science. The men responsible for their development have seldom put their knowledge on paper, hence published material on the principles of separating grain from straw and chaff is quite limited. It is hoped that in the future men with wide experience in designing grain separators can be persuaded to publish their knowledge.

A chapter is devoted to the types of hydraulic systems now in extensive use and to power-take-off drives. Both the tractor and the implement are involved in these matters, hence there may be some overlapping with a book on tractors. It would, however, be a mistake to omit them from a book on implements since the operation and the control of the implement is involved.

Appended to the book is information about standards and recommendations for V-belt drives, remote hydraulic cylinders, baling wire, power-take-off drives and implement tires.

The authors have done an excellent job in handling their subject. The book should be studied by designers of farm machinery and by every teacher of the subject on the engineering level.

A. W. CLYDE

TRANSISTORS AND OTHER CRYSTAL VALVES, by T. R. Scott. 258 pages, plates, 15 × 22 cm. London, Macdonald & Evans, Ltd.; Fair Lawn (N. J.), Essential Books, Inc.; 1955. Price, $7.50.

The transistor has received such widespread and rapid acceptance in the United States that some of us may have thought its use exclusively American. Actually, a great deal of work on semiconductor devices went on in other countries during and following World War II. One important stimulus to this work was microwave radar, and the application of semiconductors as super-high-frequency detectors was under particularly intensive development in England.

The English laboratory directed by Mr. Scott has apparently achieved considerable stature in semiconductor research. Practical results evidently have been achieved in the form of manufactured transistors, photodiodes, and crystal rectifiers. Much of the work described by Mr. Scott relates to the physics of transistors and the practical methods used to achieve control over the physical properties of semiconductors. Circuit applications of transistors are touched upon only briefly. In this respect the book does not compare with Shea's "Principles of Transistor Circuits."

The style of the book makes for easy reading by those who wish an introduction to transistor technology. Seldom becoming involved in lengthy mathematics, this author has found it possible to describe the properties of transistors in rather complete fashion through the use of clear prose, drawings and diagrams. Most of the drawings and diagrams have been borrowed from the publications of Shockley and others, through the Institute of Radio Engineers, Physical Review, and similar journals.

Unfortunately, Scott's book will be severely dated and subject to obsolescence in those sections which refer to a large variety of developmental items. Tabular data on experimental transistors, for instance, will lose their value as soon as a commercial numbering system obliterates their identity. This is merely the inevitable situation which confronts authors in the infant growth of a new field, and it is unfortunate because Scott's review of the historical achievements in the various laboratories is extremely interesting. The reader will also be interested in this author's review of the patent situation on transistor applications. Some of the information presented is a bit too detailed and includes, for instance, a listing of papers presented at technical meetings.

An excellent bibliography containing 277 items of transistor reference material is presented. Attention is also drawn to the Glen L. Martin Company's "Guide to Transistor Literature" published in 1954. In general, it may be said that this book presents a brief review of transistor and semiconductor prin-

ciples in an area of interest somewhere between that of the solid state physicist and the electronic circuit engineer. It is not sufficiently fundamental in its approach to suit the former, and the latter will wish for more on transistor circuits. C. W. HARGENS

THEORY OF ORDINARY DIFFERENTIAL EQUATIONS, by Earl A. Coddington and Norman Levinson. 429 pages, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $8.50.

The subject matter of this book falls into three main topics: The Fundamental Existence Theorems, comprising the first two chapters and about sixty pages; The Theory of Linear Equations, covered in Chapters Three through Twelve consisting of about 250 pages; and finally, The Theory of Nonlinear Systems, considered in the last five chapters of about 100 pages. Any one of these sections would provide enough material for a one semester course. The mathematical prerequisites for the book are some knowledge of matrices, the Lebesque integral, and functions of a complex variable, although a considerable portion of the book can be studied without any notions about the Lebesque integral.

This reviewer knows of no other text on the subject in the English language, with such a broad scope and with a scope so well suited to the needs of the present day pure and applied mathematicians. Its only possible competitor is Lefschetz' elegant little monograph "Lectures on Differential Equations" in Princeton's Annals of Mathematics Studies. However, Lefschetz' monograph is too concise to have the wide appeal of the book under review.

No attempt will be made to give a complete outline of the book. However, the following listing of some of the subjects covered will suffice to indicate the scope of this text. Among the chapters on linear systems, the following are considered: systems with isolated singularities of the first and second kind; asymptotic behavior of systems containing a large parameter; self-adjoint eigenvalue problems for second and higher order equations. In the latter, the Spectral Matrix and the Green's Function are discussed.

Some of the topics considered in the chapters on nonlinear systems are: stability; perturbation of systems having periodic solutions; the Poincare-Bendixson Theory; and finally, differential equations on a torus.

This book fills a gap in the literature on differential equations and should find a large audience among applied mathematicians.

H. L. PLATZER

MATHEMATICS FOR THE CHEMIST, by G. J. Kynch. 356 pages, diagrams, 14 × 22 cm. New York, Academic Press, Inc.; London, Butterworth Scientific Publications; 1955. Price, $4.80.

This is a valuable book which covers, broadly speaking, the requirements of chemistry students at universities and colleges. The level of presentation is that of an advanced course, but the topics are clearly presented, so that a selection of them can be used for more elementary courses. There are twenty chapters dealing with standard topics of algebra and differential calculus. Each chapter includes examples and problems. The only serious drawback that this reviewer has found in this volume is that a book on mathematics for chemists should be written by a chemist, just as applied mathematics for engineers should be taught by engineers. The author frankly admits that he has been involved with very elementary chemistry only. The chemist often struggles with differential equations that cannot be easily integrated by any standard method discussed in books like this one under review. Therefore, he is most anxious to know what simplifications are mathematically feasible in order to make his equation integrable. This book will be of little help to him in this and related problems. G. PARRAVANO

GUIDE TO THE STARS, by Hector Macpherson. Sixth edition, 150 pages, plates, illustrations, 15 × 18 cm. New York, Philosophical Library, 1955. Price, $2.75.

Interest in astronomy manifests itself rather early in life and the immature mind seeking a hold on the subject must content itself with the descriptive phases of this science. The solar system, from the overwhelming sun to the tiny meteors, plays an important role in this early study. Then the stars come into the picture but not from the chemico-physical aspects of these bodies

but rather from the patterns in which we find them in the sky.

Guide to the Stars is obviously written for the young and for the layman. After a brief introduction on astronomical discovery it covers the solar system from the sun to the most distant of the planets. This treatment is short, well written and wonderfully effective in its presentation. After this brief exposition the star configurations are discussed at great length.

Dr. Macpherson divides the sky up into seven areas. The north circumpolar groups, the southern skies we never see from this latitude, the zodiacal constellations and finally the normal divisions of winter, spring, summer and autumn.

It is a carefully written book with tremendous appeal to young minds and for this reason it is unfortunate that the author did not use the star names in greater measure instead of the Greek designation in terms of brightness. A knowledge of the star names is a measure of familiarity which gratifies the ego of the observer. The value of this book would have been enhanced by this inclusion.

I. M. LEVITT

THE METALLURGY OF ZIRCONIUM, edited by Benjamin Lustman and Frank W. Kerze, Jr. 776 pages, diagrams and illustrations, 16 × 24 cm. New York, McGraw-Hill Book Co., 1955. Price, $10.00.

The National Nuclear Energy Series is intended to be a comprehensive documentation of the scientific and technical achievements of the national program for the development of atomic energy. The present book fulfills this intention admirably. Since nearly all of the development of zirconium has been as a result of its use in the nuclear energy field, the text covers the known technology of this metal extremely thoroughly.

The amazing advances made in the zirconium industry are reflected by the following data: In 1943 0.08 lb. of iodide zirconium were sold at the rate of $630 per pound. Only ten years later, one company could produce 150,000 pounds per year at a cost of less than $15 per pound. The Bureau of Mines was also producing 25,000 pounds per month of sponge zirconium, at less than $15 per pound.

The remarkable development of zirconium technology has been due to its abundance, favorable fabricating properties, good corrosion resistance, mechanical properties and low absorption cross section for neutrons. Many metallurgists could deduce from these properties that zirconium would be of primary importance in nuclear reactors as a structural material. However, until the present book was published, he had to speculate as to exactly how it was used since all of the data was of a classified nature. Of course, a few scattered articles appeared in the literature that gave fairly good indications as to the use of this rare metal.

Generally, when a book is devoted to a single metal, a great deal of repititious material is presented. This is necessary in order to have a complete text. However, the same is not true for zirconium. The metallurgy of this element is not only new, but most of the information concerning it has been classified until recently. For instance, the first chapter discusses nuclear reactors briefly and covers the application and use of zirconium in reactors. This type of recently declassified information makes the book extremely fascinating reading.

Due to the necessity of maintaining a low neutron cross section for thermal reactor work, zirconium must be exceptionally pure with respect to most elements. This has a direct bearing on the exceptional quality of the data in this book. High purity is rarely needed for the successful application of most metals, thus a tremendous amount of data on impure material is accumulated and published over a period of years. Such information is in need of constant revision as knowledge is slowly amassed on higher purity metal. The editors of the present text have attempted to eliminate results that are suspect because of possible material contamination and improper processing. Consequently, they present excellent data that will undoubtedly remain unrevised for a relatively long time.

Very detailed information is given on the melting, fabrication, chemistry, metallography, corrosion, and mechanical properties of zirconium. Information is presented that will be invaluable to anyone working in these phases. Standard sections are included on occurrence, production, uses, and physical properties. A section on zirconium alloys

systems compiles all of the known phase diagrams and should be of especial interest to the physical metallurgist.

The book is profusely referenced and has both a name and subject index. It is, in this reviewer's opinion, one of the most outstanding metallurgical texts to appear in recent years. R. L. SMITH

COLOR TELEVISION FUNDAMENTALS, by Milton S. Kiver. 312 pages, color plates, drawings, photographs, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $6.00.

This author has prepared a purposeful little volume directed to those who would take up color television without the necessity of designing new equipment. That is, the book is not intended as an engineering text but as an explanation of currently used color circuits and equipment. Mathematics is relegated to the appendix, and most of the physical principles discussed can be understood by technicians without an engineering education. Practicing engineers may, however, find the specific details of color circuits presented here in a conveniently readable form, opportune for bringing their general knowledge up to date.

Essentially this book offers a minutely detailed description of several currently manufactured receivers, including many data on their circuits. One of these is the CBS Model 205. Little is said about future possibilities or developmental work. In fact, a number of tested devices such as the several kinds of picture tubes are omitted from the discussion. The reader, for instance, who has an interest in the Lawrence tube will look this up in the index. Here he will be referred to page 306 which turns out to be a blank sheet between the Appendix and the Glossary. The information on the Lawrence tube will be equally disappointing when he finds it, for only six lines are devoted to the subject. The reviewer could not find mention of the other two picture tubes which are now receiving publicity, the General Electric post accelerator tube and the Philco secondary emission device. It is surprising that some mention of the latter did not find its way into context in view of Mr. Fink's consulting editorship of this television series. Much is said about the phosphor-dot and shadow-mask picture tube.

This author's sources of illustrative material seem to have been various. Sections of schematics appear to have been extracted from manufacturers' diagrams while retaining the original component numbering system. No credit is given, and there are no references anywhere in the book to help the student find additional information. On these points some improvement would not have been difficult.

Teaching color television fundamentals by the method of dissecting commercial receivers is unquestionably effective. This author has examined the NTSC color signal requirements, the circuits for signal processing, and the waveforms throughout the system. Through the use of this volume it may be possible to train the necessary technicians who will have the intriguing task of servicing color instruments when they become plentiful. However, since the presentation is so specific, numerous new editions will undoubtedly be required to keep pace with progress in this field. C. W. HARGENS

DETERMINATION OF ORGANIC STRUCTURES BY PHYSICAL METHODS, edited by E. A. Braude and F. C. Nachod. 810 pages, diagrams, 16 × 24 cm. New York, Academic Press, Inc., 1955. Price, $15.00.

It has been with considerable interest and enthusiasm that the writer has reviewed this book. However, one must hasten to add that it was read, to a considerable extent, from a quite specific point of view—namely that of the kineticist who is always interested in becoming increasingly familiar with possible means of following the concentration of organic (among other) molecules throughout the course of a reaction. This is obviously not the principal purpose for which the book was written, as may be inferred from the title. But it is doubtful whether the editors would have any objection to their book being applied in the manner mentioned, while the application serves to illustrate the versatility of the book.

The avowed purpose of the volume is to present a review of the more widely used methods which have been developed by physicists and physical chemists while in the process of studying the basic bonding struc-

tures of organic molecules. There are in all 16 methods presented by men competent in their respective fields, and described in varying detail and with varying purpose. The 16 methods are grouped in three major parts: determination of molecular size, pattern and fine structure.

Some of the chapters such as the one on Magnetic Susceptibilities seem to be much more complete than others, with regard to their exposition of the fundamentals involved in the particular phenomena under consideration. However, the principal merit of the book lies not in the completeness of the descriptions of the individual methods. It is rather in the fact that the methods are collected in one volume and in sufficient detail to provide with an encyclopedic type of reference, the researcher who is considering an application of a physical chemical method which differentiates between bonding structures of organic compounds. It would be useful if other methods could be added in succeeding volumes. A. L. MYERSON

TRANSMISSION-LINE THEORY, by Ronold W. P. King. 509 pp., diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., 1955. Price, $12.00.

Most electrical engineers practicing in the field of communications have, through the years, come upon numerous writings of Ronold King. Long associated with Harvard's Cruft Laboratory, he is well known for his analytical work on the theory of antennas. His new book on transmission-line theory has been prepared in the same careful and thoroughly professional manner. It is a highly mathematical work presented with formal elegance.

Perhaps an old subject, transmission-line theory is so basic to the science of communications that it has received the attention of many of the best known workers in this field. The engineering analysis of telephone lines was stimulated in the early '20's as this important commercial facility grew. The electromagnetic view of the subject was studied much earlier. However, Professor King's new book will be considered a contribution to the engineering side of the literature. In its attack upon the "old subject," this book brings much that is new in its extension of engineering analysis.

The need for extension of analytical methods as applied to transmission lines stems perhaps from the ever increasing frequencies that are finding practical use. This increase in frequency is itself important, but the resulting critical geometry involved in the design of discontinuities in the lines is most significant to the engineer.

In addition, it should be pointed out that we are now using transmission lines for many applications which are not strictly transmission. Transmission lines with either distributed or lumped constants are used in high frequency oscillators and in pulse-forming circuits. In the case of oscillators employing various transmission line configurations, the author has presented the relations governing coupled sections of line. Line elements also find application in computers and other electronic systems where the time delay of impulses is required. Professor King has, therefore, taken up the detailed analysis of many of these special applications, presenting them in the formal perfection usually accorded to the fundamental transmission line. Used as a text or reference, this book is undoubtedly one of the most complete treatments of this subject to date. C. W. HARGENS

ELECTROLYTE SOLUTIONS, by R. A. Robinson and R. H. Stokes. 512 pages, diagrams, 15 × 22 cm. New York, Academic Press, Inc., 1955. Price, $9.50.

As the title indicates, this book deals with only certain aspects of the physiochemical properties of electrolyte solutions. But the topics chosen for discussion, conductance, chemical potential and diffusion, are thoroughly presented and treated. There is enough theory in the book to satisfy a theoretical minded reader, but there is also a good deal of experimental presentation and details for practical electrochemists, as the authors define themselves. The result is a clear, up to date, and thorough book on electrolyte solutions.

The first four chapters are devoted to a general discussion of electrolyte solutions: properties of ionizing, solvents, basic concepts and definitions, the state of the solute in electrolyte solutions, ionic distribution function and the potential.

The following three chapters discuss electrolytic conductance, measurement of conduc-

tivities and transport numbers, limiting mobilities of ions, variation of conductivities and transport number with concentration. The measurement and interpretation of chemical potentials are presented in the following two chapters.

The remaining chapters are concerned with: measurement of diffusion coefficients, the theory of diffusion of electrolytes, weak electrolytes, strong acids, ion association, the thermodynamics of mixed electrolytes. The treatment is based on the interionic attraction theory of Debye and Hückel, and later developments by Onsager, Fuoss and Falkenhagen are included. The treatment deals mainly with aqueous solutions of electrolytes, but some recent data of non-aqueous solvents are also included. Several tables of experimental data (specific conductivities, equivalent conductivities, standard cell potentials, activities, osmotic coefficients etc.) are included at the end of the book.

G. PARRAVANO

THE FABULOUS PHONOGRAPH, by Roland Gelatt. 320 pages, plates, 15 × 22 cm. Philadelphia, J. B. Lippincott Co., 1955. Price, $4.95.

Edison acquired his first talking-machine patent in 1878 and since that date there has been a constant development until, eventually, the current high fidelity phonograph was achieved. The progress has been performed without any organized or adequate history of the instrument having been written. The author of this book is the New York editor of *High Fidelity* monthly, in which periodical a portion of the book has appeared in serial form. He has done a praiseworthy job in presenting an unprejudiced picture of the industry and the phonograph as a musical instrument. This cannot have been an easy task, for there were many conflicting stories to be reconciled. Mr. Gelatt has done prodigious research work to assemble all his material, and he has presented it in an interesting manner.

Formidable handicaps confronted the makers of the earliest talking machines, one can scarcely dignify them by any other name, for few efforts were made to record sounds other than the human voice, and these were played through the original "juke boxes" to be heard by the listeners through ear tubes. Today, when discs are made by the thousand it is difficult to realize the first records had to be cut individually. The momentous change, signalizing the conversion from cylinder to flat disc records and the prospect of making manifold impressions from a master was announced at a meeting of The Franklin Institute in 1888. Emile Berliner, the inventor of disc recording, at that meeting also announced the possibility of the phonograph becoming an instrument for home entertainment, now that multiple records were technologically and economically possible. The stampede for famous singers followed and, afterwards, for the best known orchestras. Most people will be surprised to learn that the first "Red Label" records appeared in 1901 in, of all places, Russia.

This book will long remain the authoritative source of information upon the musical fare provided by the record companies. Great care has been devoted to running down the various "firsts," and much of the material will be read for the first time by American readers, for many of the progressive steps were made in Europe.

The book claims to be a history "of an invention, an industry, and a musical instrument." The claim is justified so far as the two latter features are concerned, but it is wanting in regard to the inventive aspect. When a new edition is called for, which cannot be long deferred, it is hoped Mr. Gelatt will enlighten his readers upon the struggles to overcome some of the engineering problems. For example, on the frantic search for a suitable diaphragm material, which extended to the inclusion of tuna fish scales, before mica was chosen. Or in the persistent efforts made to reduce the processes between the wax disc on which the recording was cut and the matrix that produced the final pressings. We feel that some of these stories are just as important as the struggle to secure the exclusive services of a great singer.

T. C.

THE METHOD OF TRIGONOMETRICAL SUMS IN THE THEORY OF NUMBERS, by I. M. Vinogradov, translated from the Russian, revised and annotated by K. F. Roth and Anne Davenport. 180 pages, 16 × 24 cm. New York, Interscience Publishers, Inc., no date. Price, $5.00.

This book is essentially a translation from the Russian of Vinogradov's monograph

with the same title, originally published in Travaux de l'Institut mathematique Stekloff, Volume XXIII (1947). The principal changes in the text have been an enlargement of the detail in the more difficult arguments and the addition of notes at the end of each chapter. These notes contain a discussion of the changes in the text as well as a general commentary on the subject matter of the chapter.

The book is devoted to the consideration of various special cases of three general problems:

1. To establish an upper bound for the absolute value of the sum

$$S = \sum_{\Omega} \exp (2\pi i F(x_1, \cdots, x_r)$$

extended over the integer points $(x_1, \cdots, x_r)$ in the set Ω, it being understood that the total number of these integer points is finite, and F is a real function.

2. Any real number α has an integral part and a fractional part. The fractional part is denoted by $\{\alpha\}$. The second class of problems is concerned with the distribution of the values of the fractional part of the function $F(x)$, that is, with the values of

$$\alpha(x) = \{F(x)\}$$

where $F(x)$ is a real function and x takes on all integral values in some interval $Q \leq x \leq Q + P$.

3. Let N be an integer. The third class of problems is concerned with the number of solutions of

$$f(x_1, \cdots, x_r) = N$$

for $(x_1, \cdots, x_r)$ in some set Ω. The problem might be to determine whether there is at least one solution in Ω, or more definitely the problem might be to determine an asymptotic formula or even an exact formula for the number of solutions of this equation. Several famous problems in the theory of numbers are special cases of this problem, namely, Waring's problem (1770) and Goldbach's problem (1742).

The fundamental principle of Vinogradov's method is based on the fact that it is possible to estimate effectively sums of the form

$$\sum_{u} \sum_{v} \exp (2\pi i \alpha u v)$$

under very varied conditions of summation on u and v.

Because the arguments used in some of the problems are frequently lengthy and involved, it is not always easy to see the unity of ideas underlying the discussion of the various problems considered. The translators have underscored this unity and have thereby emphasized the power and ingenuity of Vinogradov's method. H. L. PLATZER

FRONTIERS OF ASTRONOMY, by Fred Hoyle. 360 pages, plates, diagrams, 15 × 22 cm. New York, Harper & Brothers, 1955. Price, $5.00.

If this reviewer were once more a student in astronomy, he would endeavor to do some of his graduate work at Cambridge University in England.

At this university are to be found some of the shrewdest and most articulate men in astronomy. Many new and revolutionary astronomical concepts have originated there and the personable spokesman for the group is the author of *Frontiers of Astronomy*.

In 1954, Fred Hoyle visited this country and stayed at the various observatories speaking with the American leaders in the field. In astronomy there have been fantastic developments simply because "gadget" minded America can afford the newest, largest and most precise equipment its scientific leaders demand. For this reason it is to be expected that the most recent and significant discoveries should have been made here. Last year Dr. Hoyle steeped himself in these developments and then went home to write a book. *Frontiers of Astronomy* is the result.

The book is written in the easy, free-swinging style which readers met in the author's first book, "The Nature of the Universe." It is fascinating reading and at the same time packs a scientific punch of considerable magnitude. The latest discoveries and developments are incorporated to make it authoritative and up-to-the minute.

Dr. Hoyle treats the basic bodies in astronomy in the beginning of the book (there has been little change in this knowledge over the past 50 years) to get them out of the way so that he can bring into focus the de-

velopments which have to do with the structure of the universe. He is superbly clever in laying the groundwork for the introduction of the new distance scale by speaking about the different populations of stars and following them with a lucid description of the cepheid variables—the lighthouses of the sky used for distance determination—and the realization that these too follow the pattern of the ordinary stars and fall into two categories. He shows that the discrepancies which handicapped the astronomers of 10 years ago in trying to find a compatible distance scale resolves itself when it was recognized that the cepheids were not alike. From this point on the development shows that the universe must be expanded by a factor of about three.

Until quite recently the velocity-distance relationship indicated that the "velocity of recession" was about 100 miles per second for every million light years of distance. Today the 100 miles per second must be used for galaxies three million light years away. This has in effect tripled the size of the universe under observation with the 200-inch telescope. We now feel that the penetration with this instrument has been made to a depth of 3,000 million light years.

When Dr. Hoyle deals with the "realm of the nebulae" he is on safe, sure ground which he handles with authority. When Dr. Hoyle deals with the solar system he speculates perhaps a little too freely. He apparently accepts the findings of Holmberg too literally with its consequence that the earth will lose the moon to the sun. In his discussion of the ice ages no mention is made of the carbon dioxide effect which to this reviewer is most important. Volcanism with its release of tremendous amounts of dust and carbon dioxide cannot be overlooked as a possible cause of the ice ages. Incidentally he makes the equatorial diameter of the earth 54 miles greater than the polar diameter which is too large by a factor of two. (I wonder how much shorter the day would have to be for this condition.) However, these are but minor points and in no way detract from the value of this book.

Frontiers of Astronomy is a distinguished astronomical contribution. I. M. LEVITT

QUALITATIVE ORGANIC ANALYSIS AND SCIENTIFIC METHOD, by Alexander McGookin. 155 pages, 15 × 22 cm. New York, Reinhold Publishing Corp., 1955. Price, $4.50.

This is an elementary treatment of analytical organic chemistry, written mainly for teaching purposes. Its main feature is its simplicity, and clarity of presentation and thought. Throughout the book, the thread that extends from the initial problems, to the various tests, and to the final deductions is emphasized. The analytical scheme described involves: preliminary tests (appearance, odor, melting and boiling points, action of heat, ignition with soda-lime, solubility, reactions with alkali and acids, detection of various elements), special tests (permanganate, bromine water, Schiff's, Tollen's, Fehling's, Molisch's, Barford's reagents and treatment with ferric chloride, phosphorous pentachloride, picric acid, oxidation, fusion with potash, nitration etc.)

Although the material covered is rather large for a relatively small book, this cannot be considered a general reference book on qualitative organic analysis. The book, however, will be much appreciated and found quite useful by teachers and students alike for its stress on logic and clear thinking.

G. PARRAVANO

INSTRUMENTS FOR MEASUREMENT AND CONTROL, by Werner G. Holzbock. 371 pages, illustrations, 15 × 23 cm. New York, Reinhold Publishing Corp.; London, Chapman & Hall, Ltd.; 1955. Price, $10.00.

In view of the current popularity of automation and process control among industrial engineers, books on the various aspects of automatic control are apropos. These books usually divide into those treating either the theoretical or the practical aspects of the subject. Among the former group one thinks of servomechanism theory, circuit design, and instrument analysis, subjects on which we have excellent technical writings. However, the practical side of controls engineering is pretty nearly left to trade publications and catalogs published by the manufacturers.

Werner Holzbock has undertaken to collect representative examples of instruments which he has classified under their fundamental uses in connection with temperature, flow, density, viscosity, et cetera. It is

pointed out that there is a limit to the number of basic principles used in the sensing or control of the various measured quantities, and these are reviewed for each case. Examples of commercial instruments are sketched schematically with an accompanying description of their operation.

This is about as far as the author has gone in helping the engineer with his task. That is, the book will serve only to indicate the generally available alternatives in selecting a measuring or controlling method to handle a particular quantity such as viscosity. The equally important questions of accuracy in terms of static or dynamic response are left for the engineer to investigate. This information is available to some extent through the manufacturers and could have been included if the author had seen fit to do so. Of course valid reasons for the exclusion of such specific information do exist and include its tendency toward rapid obsolescence. Moreover, it may have been the author's wish to avoid the pitfalls of comparing in detail the capabilities of instrumentation vigorously championed by various firms.

For a rapid summary of techniques this volume serves very well. However, for an analysis of these techniques in operation, the engineer must turn to more fundamental texts or exercise his own analytical skill.

C. W. HARGENS

SOUND BARRIER, by Neville Duke and Edward Lanchbery. Sixth Edition, 129 pages, plates, 13 × 19 cm. New York, Philosophical Library, 1955. Price, $4.75.

In 1953 the first edition of *Sound Barrier* appeared. Two short years later the sixth has come off the presses. For a book to go through this many editions means that it fulfills a definite need and also the state of the art is in such tremendous flux that revisions are necessary.

This books deals with flight—subsonic, transsonic and supersonic—and therein is found the wide appeal for this work. Only within the past decade has the combination of scientist, engineer and pilot produced the hardware to "barrel" into the supersonic range and the multitude of problems which resulted are still under investigation.

The author, a renowned jet pilot, wisely introduces the concept and origin of the term, sound barrier. He writes: ". . . an expression that first gained prominence after a forecast by Dr. W. F. Hilton of Armstrong-Whitworth, that as an aircraft neared the speed of sound, drag would rise suddenly 'like a barrier against the future.'" The idea that this was a "physical" barrier is quite false. Today we have operational jets in the supersonic range.

A full description of the airplane and air behavior explains the effects in passing into the supersonic range. The author even includes the several theories to explain the phenomena of sonic bangs.

In section II, Design for Speed, the hardware—both engine and aircraft—and the pilot are fully covered. The theory of jet propulsion with all its ramifications is covered in detail. The evolution of the airplane so that it could withstand the high speeds and the reasons for the odd shapes of present day aircraft are unfolded. Finally the physiological effects of high speeds, accelerations, low pressure, etc. on the pilot are explored.

In Part III, Design for Use, the wedding of practical consideration to ideal theoretical requirements and the necessary compromises to yield an effective aircraft are considered. This reviewer has always wondered why and how the "delta wing" design came into being. An excellent description is given of how wings were swept back more and more and then filled in at their trailing edges to provide the necessary lift.

At this writing the "Coke bottle" shape of high speed craft is in the news and already this sixth edition is dated. However, as long as research continues, future editions or complete rewrites will be necessary.

I. M. LEVITT

ELECTRONIC TRANSFORMERS AND CIRCUITS, by Ruben Lee. Second edition, 360 pages, diagrams, 15 × 23 cm. New York, John Wiley & Sons, Inc., 1955. Price, $7.50.

The author of this book has been for many years a recognized authority in the field of inductive devices and components. His first book, published in 1947 under the same title, was well received as a clear, concise, and practical text on the design of transformers for electronic apparatus. Since the war, new advances in this rapidly expanding field have

created a need for a second edition of this already popular text.

The present volume has retained most of the material of the first edition except for a few cases where it was felt that more thorough treatments were readily available in current literature. In addition, two new chapters on magnetic amplifiers and pulse circuits have been included. The design and construction of transformers and inductors for a great variety of electronic applications are treated in the other chapters.

The text is very practical. Little theory is included, but rather charts and tables, and numerous illustrations cover the complete design procedures for the various transformer and reactor types. In many cases, complete examples are worked through step by step. Available materials and construction techniques are also carefully described.

Because of its very broad coverage some parts of the book are sketchy, but the generous number of references to papers and other texts should help the reader through these areas. Students undoubtedly will desire more thorough treatments than are provided in the present text, but the designer and engineer confronted with problems in this field will find it a valuable up to date handbook with a better than usual supply of pertinent information well indexed and easily located.

D. L. BIRX

METEORS, edited by Dr. T. R. Kaiser. 204 pages, plates, diagrams, 19 × 26 cm. London and New York, Pergamon Press Ltd., 1955. Price, 55s.

The post-war instituting of new experimental and observational techniques has given marked impetus to a branch of astronomy which has been in the doldrums.

Meteors are an elusive, evanescent astronomical phenomenon which, in the past, depended on observations ranging all the way from those of the skilled observers and rank amateurs to the casual layman who just happened to be looking skyward when a meteor plunged into the atmosphere. As a result, not only was meteor astronomy neglected, but it was a field generally avoided by the upcoming generation of astronomers. With the war and introduction of new observational techniques and the development of new optical and electronic equipment, a resurgence of interest became manifest. This reviewer is hardly likely to forget the tremendous enthusiasm and interest engendered by the announcement at a meeting of the American Astronomical Society of the daytime detection of meteors by radar. Today meteor astronomy is in its ascendancy and striking contributions to this discipline can be expected.

New observational techniques with the aid of super speed cameras, modified and new radio gear have accelerated progress in this field from statistical studies to the physics of the upper atmosphere as determined by meteors. The progress of this field is so widespread that in July 1954 a symposium on meteor physics was held at the Jodrell Bank Experimental Station of the University of Manchester. The papers presented at this meeting were published and *Meteors* is the collection.

Contributed papers at this symposium came from the recognized leaders of the field from many countries. Names like Whipple, Thomas, Opik, Nicolet and Fessenkov are indicative of the calibre and origin of the contributors. In all some 49 papers were presented by almost this many contributors. The topics covered included meteor ablation, luminosity and ionization; spectra, radio echoes from meteors, meteor influences on the atmosphere; determination of upper atmospheric pressures and winds from meteors; evolution of meteor streams, meteors and interplanetary dust, etc.

Meteors is a significant contribution to a lusty infant science. By this publication Pergamon Press has earned the thanks of the astronomical profession.

I. M. LEVITT

CHEMISTRY OF THE SOLID STATE, edited by W. E. Garner. 417 pages, diagrams, 16 × 25 cm. New York, Academic Press, Inc., 1955. Price, $8.80.

In recent years we have witnessed two important advances in the field of Solid State Physics. As a consequence, a renewed interest in the more chemical aspects of solids was to be expected. Actually the two points of view, physical and chemical, cannot be separated. It is the task of physical chemistry to bring about a harmonious synthesis between them. Therefore, it is quite inter-

esting to see a distinguished group of physical chemists treat in the 15 chapters of this book some of the most modern aspects of the physical chemistry of solids. The result is clearly a first rate book, and an important addition to the rapidly increasing bibliography on solid state behavior. It is strictly a "British" textbook. Whether this was done purposely or not, all the contributions to the book under review come from English laboratories. Most of them bear the trade mark of the Bristol school, which the editor so successfully built over the past decades. The subjects discussed include: the chemistry of crystal dislocation, (Frank), lattice defects in ionic crystals (Stone), action of light on solids (Jacobs and Tompkins), surface of solids (Jacobs and Tompkins), semiconductivity and magnetochemistry of the solid state (Gray), theory of crystal nucleation from vapor, liquid and solid systems (Dunning), classification and theory of solid reactions (Jacobs and Tompkins), kinetics of endothermic solid reactions (Garner), kinetics of exothermic solid reactions (Garner and Bircumshaw), decomposition of organic solids (Brown), explosion and detonation in solids (Ubbelohde), solid-solid reactions (Welch), photographic process (Mitchell), oxidation of methods (Grimley), electronic factor in chemisorption and catalysis (Stone).

The interest of the subject matter, the originality of presentation and discussion make each chapter of this book very interesting and stimulating reading, despite the fact that some of the subjects treated present aspects which are still of a controversial nature (properties of solid surfaces). It is, probably, only natural that one school of thought tends to emphasize facts and conclusions which are its own, and belittle, or ignore altogether, other facts and experimental observations which would lead to opposite and therefore unpleasant conclusions.

G. PARRAVANO

PLASTICS FOR CORROSION-RESISTANT APPLICATIONS, by Raymond B. Seymour and Robert H. Steiner. 423 pages, illustrations, 15 × 23 cm. New York, Reinhold Publishing Corp.; London, Chapman & Hall, Ltd.; 1955. Price, $7.50.

The application of plastics and resins where chemical inertness is required has opened an entirely new field in the fight against corrosion. But, as is true for any new field of endeavor, the lack of competent technical and engineering data is a grave obstacle in its growth. Improper use of these new materials can do great damage to both manufacturers and processors.

This book is intended to fill the quest for comprehensive technical information which shall serve the engineer as well as the user. It has been written by men who have collected their know-how by extensive practical experience and are most competent in the field. Except for a brief treatment of the physical and chemical properties and their interrelationship, the authors avoid any deep theoretical treatment of corrosion processes or plastic formulation. They stick closely to their main objective to supply the engineers with the necessary background for selecting the right material to be used in corrosive atmospheres.

The plastic materials of construction are presented according to their application as protective coatings, organic linings, chemical resistant mortar cements, casting resins, cellular plastics, plastic impregnants, industrial adhesives and reinforced plastics.

Throughout the book the different plastics are compared with each other in numerous tables in respect to their mechanical and chemical properties.

In a separate section the use of thermoplastics as structural materials is treated. For a long time the fabrication of thermoplastics was considered too difficult. The thermal welding has become an important method for fabricating simple structures. Although suggested almost twenty years ago, the plastic welding art was not developed commercially in this country until recently. Today this particular use of thermoplastics is steadily increasing.

Plastic pipes, ductwork, valves and fittings and the use of plastic for corrosion-resistant floors and processing vessels are described.

The text is supplemented by sketches and photographs. Following each paragraph references for further information and study are given.

Plastics for Corrosion-Resistant Applications will find its way to many different technical fields. As a guide in selecting the proper material for each individually different situation, this book will be very helpful.

Technically usable information is made available without burying it under an excess of theoretical discourse. K. SITTEL

FUNDAMENTALS OF TELEVISION ENGINEERING, by G. M. Glasford. 642 pp., diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $12.75.

Professor Glasford's new book on television engineering suffers from brevity in spite of its 642 page length. This is the difficulty that besets authors who attempt to cover a large branch of engineering in a way that was entirely possible several decades ago. When F. E. Terman wrote his "Radio Engineering," it was not too difficult to include all of the established information on vacuum tube circuits within a single volume.

At that time, the circuits to be treated were essentially a variety of amplifiers and oscillators. The frequencies then in use did not yet include the VHF, UHF and microwave regions with their attendant complexity. Antenna systems had not acquired the elegance which they now possess. It is true, therefore, that we have reached a point in the technical development of communications where a single-volume treatment can do little more than introduce the subject.

Of these introductory books we now seem to have a great many. There is nothing wrong with this situation provided our educators in the technical schools recognize the facts. The facts are that a student engineer trained with this type of summary material does not have the knowledge to carry out original research or development tasks. Engineering degrees should not be awarded upon completion of a number of general courses, but only when engineering proficiency, commensurate with the real demands of the profession in our time, has been demonstrated in some particular field.

Professor Glasford's book covers some aspects of circuit design with sufficient detail to provide the student with a genuine engineering exercise. In other places he has included material of a brief, descriptive nature which is too incomplete to benefit the student in any way. This is exemplified by a section on "Waveguides and Resonant Cavities." This section is only three pages long, is so brief that it cannot serve even as an introduction to the subject, and has little to do with television. The analysis of resonant cavities consists of a single equation which states that the Q of a cavity is the ratio of the energy stored to the energy lost per cycle. Although true, it is certain that this alone would not be of very much help to one faced with the problem of designing a microwave device. Fortunately, the author does make reference to another text.

There seems to be a sort of incompatibility in the material which comprises a book of this type. That is, the level of the work shifts between extremes, at one moment elementary, the next, advanced. Some parts of the text are presented with photographs of cathode-ray tubes and equipment consoles while others treat the transformation calculus. This gives the appearance that the author had gathered together everything encountered in his travels relating to the subject of television and crammed it into his book without regard to purpose. Transient analysis of circuits by transform methods, for instance, seems to be one of these incidental subjects, for it is not used in other parts of the book.

The book will certainly not serve as a reference for engineers who must use more specialized volumes on the specific aspects of television such as receivers or antennas. It may serve as collateral reading for those entering the field of communications. These persons will require a college-level mathematical background to appreciate some portions of the book, patience to read the descriptive material on the broad variety of subjects treated, and the wisdom to undertake more concentrated courses in basic communications and electronics.

C. W. HARGENS

MECHANISM, by Joseph Stiles Beggs. 418 pages, illustrations, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $6.50.

Liberally interspersed with line drawings, full view and cut-away pictures, and containing a text that adequately supplements the illustrations, this book on a fundamental branch of mechanical engineering provides a good introduction into mechanisms. Written by a former associate professor of Engineering at U.C.L.A., *Mechanism* was specifically prepared for an advanced course in kinematics.

Following two introductory chapters on design in general and the fundamentals of mechanics, the author discusses gears and gearing, cams, rotary drives, linkages and links, from the viewpoint of the basic interrelations involved rather than from the viewpoint of structural design. The latter half of the book deals with such specific mechanisms as computing machines; the control of mechanisms; and such special topics as kinematics of geometrical optics, evolution of geometrical forms, and systematic design. The concluding chapter is a repertory of various mechanisms in the form of illustrations with brief descriptions of their functions and uses.

The author jumps too quickly into specific details without adequately introducing the subject. His descriptions also seem too clipped and terse. E. W. HAMMER

PROBLEMS AND CONTROL OF AIR-POLLUTION, edited by Frederick S. Mallette. 272 pages. illustrations, 16 × 24 cm. New York, Reinhold Publishing Corp., 1955. Price, $7.50.

This volume, edited by the executive secretary of the Committee on Air Pollution Controls of the American Society of Mechanical Engineers, contains the papers presented at the First International Congress on Air Pollution held in New York City on March 1–2, 1955 under the sponsorship of that committee. In addition to the technical papers presented at the various sessions of the congress, the Calvin W. Rice lecture given by Sir Hugh E. C. Beaver and an address by G. Edward Pendray are included. The first speaker reviewed the British smog problem under the title "The Growth of Public Opinion" while the latter delivered an after dinner speech entitled "Management Aspects of Air Pollution."

The technical papers are divided into four groups of four to eight papers each, making a total of twenty three papers which present a cross section of the widely varied aspects of air pollution. The first group of papers is labeled "Gaps in the Available Knowledge on Air Pollution" and covers biological, administrative, engineering, meteorological and health problems. The second section "Current Developments in Air Pollution" cannot be summarized since no two of the four papers are on a similar subject, ranging as they do from a study of light scattering by aerosols to a review of the history of air pollution in Sarnia, Ontario.

The third section presents an exception to the inhomogeneity so noticeable in the other sections of the book. Its title "Sulfur Dioxide—Treatment and Recovery" adequately describes the eight papers in this section which is particularly complete since the sulfur dioxide problems faced by several major industries ranging from power plants to oil refineries are reviewed. The fourth and last section, "Experience in Air Pollution Abroad," contains reports from The Netherlands, Portugal, Italy and France. The title is somewhat misleading for while some of the authors do attempt to review the air pollution situation in their respective countries, others present technical reports on specialized topics ranging from cyclone dust separators to plant damage.

The papers are practically all well-written in easily readable styles. While the volume cannot serve as a complete survey of air pollution it nevertheless will be a welcome addition to any air pollution library, since almost every aspect of air pollution is represented by at least one paper.

EDGAR R. STEPHENS

NUCLEAR AND RADIOCHEMISTRY, by Gerhart Friedlander and Joseph W. Kennedy. 468 pages, illustrations, 15 × 24 cm. New York, John Wiley & Sons, Inc., 1955. Price, $7.50.

Nuclear and Radiochemistry is a book which should be of interest to engineers and physicists who are or intend to be associated with nuclear engineering developments, in addition to the chemists for whom the volume was written. The authors have so succeeded in presenting a wealth of fundamental material in this field that it would almost appear as though the use of the word "chemistry" in the title may restrict the readership, which this reviewer hopes will not occur.

The present volume has a forerunner "Introduction to Radiochemistry." Of the present text, about 35 per cent is based upon material in the first book; in essence, this is a completely new work. The subjects treated are those of present day nuclear technology, especially that part which can be associated with research and laboratory operations. Much information previously scattered in the literature has been consolidated so that a graduate student or one at senior undergraduate level, who at the same time is obtaining laboratory training, should have no difficulty in comprehending the subject matter.

The thirteen chapters and seven appendices treat essentially three topics: the physics of nuclear reactions; laboratory techniques for the detection and production of nuclear materials whose properties are specified; and the applications of nuclear products and energy for peaceful and military purposes. Six chapters are devoted to the first of these categories, some with more detail than others, but on the whole reasonably well balanced. A nuclear process is one wherein a nucleus reacts with another nucleus, an elementary particle, or a photon to produce one or more nuclei or other particles, usually in a time interval less than one microsecond. To study such reactions the authors consider: energy, mass and charge relations; radioactive decay and growth; chain reactions and resonance processes; nuclear states and transition and selection rules; and the interaction of various types of radiation with matter.

The growth of the field of nuclear physics and engineering would have been impossible without the development of laboratory instruments and techniques for the production, study, detection and measurement of nuclear reactions. The four chapters devoted to these topics consider the most modern instruments. Particle accelerators, ion collection devices and electronic instruments which give a researcher a statistical characterization of the nuclear processes are more than adequately described if the reader will supplement the text with some reading of the listed references, or with concurrent laboratory effort.

The applications of nuclear products which the authors have selected for inclusion in the text are drawn primarily from tracer chemistry, with one chapter each devoted to nuclear reactors and the energy production in the cosmos.

As was stated above, the authors prepared this work primarily as a textbook for chemists. This, however, should not be a deterrent to engineers, physicists and chemists who have long since passed the gates of formal training. The book is well written and easily read. Wide acceptance of the book is predicted. S. CHARP

FIFTH SYMPOSIUM (INTERNATIONAL) ON COMBUSTION. COMBUSTION IN ENGINES AND COMBUSTION KINETICS. 802 pages, illustrations, 18 × 26 cm. New York, Reinhold Publishing Corporation, 1955. Price, $15.00.

This book contains a compilation of 101 papers presented at a symposium at the University of Pittsburgh in August–September, 1954. Forty-five papers cover the important subject of kinetics of combustion reactions. Forty-five additional papers discuss the combustion of fuel droplets, propellant burning, combustion of solids, combustion in engines, diffusion flames and carbon formation, special techniques and instruments, flame spectra and dissociation energies.

Eleven additional invited papers are designed to keep workers abreast of developments in the combustion field. The titles of these papers and the names of the authors are: 1. Combustion Problems in Internal Combustion Engines, W. G. Lovell. 2. Combustion Problems in Diesel Engines, P. H. Schweitzer. 3. Combustion Problems in Liquid-Fuel Rocket Engines, S. S. Penner and P. P. Datner. 4. Unsolved Problems in Solid-Propellant Combustion, Richard D. Geckler. 5. Problems of Turbo-Jet Combustion, Peter Lloyd. 6. Combustion Problems in Ramjets, J. P. Longwell. 7. On the Kinetics of Elementary Gas Phase Reactions at High Temperatures, Kurt E. Shuler. 8. Survey of Collision Processes in the Combustion of Hydrocarbons, A. R. Ubbelohde. 9. Chemical Kinetics of Hydro-

carbon Combustion, Guenther vonElbe. 10. Space Heating Rates and High Temeprature Kinetics, W. H. Avery. 11. A Theory of Space Requirements for Combustion Behind Grids in a Closed Duet, Joseph Jennissen.

The above survey papers include discussions of combustion instability with special reference to liquid and solid propellant rockets. This problem has plagued engineers since the beginning of modern rocket development.

The introduction by Professor Hoyt C. Hottel is especially pertinent in which he states "the adequacy of our engineering knowledge of combustion is for engineering purposes in large measure tested by our ability to determine the space requirement for combustion"; and this is directly or indirectly the subject of many of the papers.

In reviewing these papers it is obvious that considerable progress has been achieved in correlating the reactivity of complex hydrocarbon molecules within the processes of energy transfers among the bands within the molecule. About half of the 45 contributed papers on chemical kinetics deal with the combustion of hydrocarbons.

This book is indispensable as a reference source of information to anyone in the combustion field. F. L. JACKSON

FUNDAMENTALS OF TRANSPORTATION ENGINEERING, by Robert G. Hennes and Martin I. Ekse. 520 pages, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $8.50.

This book covers an ambitious program in various fields of transportation, mainly viewed from the civil engineering aspect. It includes road building and highway location, airport layouts and runways, railroad engineering with discussions on permanent way and motive power performance characteristics, rivers and harbors, and, finally, pipe lines and belt conveyors. The book is mainly of a descriptive nature, though some preliminary design data are included.

In the opinion of the reviewer, the book is not a fundamental exposition on the various phases in transportation engineering. It includes compiled data, but without careful analysis and interpretation.

In the section on railroad engineering pertaining to locomotive performance, the A. R. Eng. Assoc. performance data are used, without any technical discussion of the limitation of these formulas. The power curves in terms of horsepower per ton on drivers is an assumed "statistical" exponential curve in terms of a speed ratio, where the basic speed is determined at the point where the maximum adhesion output per ton at drivers equals 0.632 of 80 per cent of the rated output per ton at drivers. The validity of this method is at best questionable, since the relation of adhesion limits and power capacity are fairly arbitrary. The continuous rating depends upon the heating limitations and motor proportions. The continuous torque at rated speed gives the rated output and this is limited by engine output. The starting tractive force, in turn, depends upon the permissible overload torque relative to its continuous rating and this in turn must be compatible with limiting adhesion. The speed range, physically, is some definite factor of the continuous rating speed. The output characteristics of modern Diesel electric locomotion is more nearly of a constant output curve against speed except in the adhesion or starting range, where the output increases nearly linearly with speed, and at extreme speeds where there is some falloff in power. Again with steam locomotives, cylinder performance is limited by boiler capacity. With adequate boiler capacity, cylinder performance gives very closely a linear dropoff in tractive force and a corresponding parabolic power curve and not an exponential curve. Again, a more fundamental analysis is needed to even approximately arrive at the performance characteristics of a locomotive.

The danger of a book of this type, in seeking an over-all review of fundamentals, is the inadequacy of space for a careful and sufficient presentation of the topics considered, and the necessity of presenting much statistical and catalogue data for some, without sufficient analysis for its justification.

RUPEN EKSERGIAN

BOOK NOTES

A TEXTBOOK OF SOUND, by A. B. Wood. Third edition, 610 pages, illustrations, 15 × 23 cm. New York, The Macmillan Company, 1955. Price, $6.75.

This new edition of a standard text brings up-to-date the main principles of sound. The new material is primarily in the fields of ultrasonics, hearing, noise, and the technical applications of sound. The references also have been brought up-to-date. This study of the physics of vibrations is suitable for undergraduate study and as a reference work in the field. The third edition will be welcomed by those who still refer to the second edition (1941).

ABSTRACTS OF THE LITERATURE ON SEMICONDUCTING AND LUMINESCENT MATERIALS AND THEIR APPLICATIONS, compiled by Battelle Memorial Institute. 200 pages, 23 × 29 cm. New York, John Wiley & Sons, Inc., 1955. Price, $5.00 (paper).

This is the 1954 volume in the series initiated by the Electrochemical Society to serve the people interested in this rapidly growing field. Greater detail for the individual abstracts is a feature of this 1954 issue, which contains abstracts of more than 750 articles. This series represents a real service to the busy engineers and scientists who cannot keep up with the flow of papers in the field.

ELEMENTARY STATISTICS, by R. Clay Sprowls. 392 pages, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $5.50.

Written by a professor of Business Statistics at the University of California, this book is intended for students of the social sciences and business. The book is based on the premise that statistical inference—the art of making decisions based upon incomplete information—is of value to business managers. The book deals mainly with the problem of making decisions (sometimes incorrectly) from such things as statistical statements, arguments and reports. It is doubtful, however, whether some of the formulae presented in the text will have much significance for business men.

AMERICAN MEN OF SCIENCE, edited by Jacques Cattell. Ninth edition, VOLUME II, THE BIOLOGICAL SCIENCES. 2180 pages, 23 × 29 cm. New York, R. R. Bowker Co., 1955. Price, $20.00.

Some 25,000 American and Canadian biologists are listed in Volume II of the colossal three-volume edition of this well-known reference work. Over fifty fields are covered in this second volume, including botany, bacteriology, entomology, neurology, pathology, public health, anatomy, physiology, forestry, genetics, zoology, medical research, mental diseases and pharmacology. Each entry, as in Volume I, contains the scientist's full name, position, educational background, professional career, his specialty, his memberships in professional societies and biographical data. Volume III in this ninth edition, covering Social Sciences, is scheduled for the summer of 1956.

HANDBOOK OF ENGINEERING MATERIALS, edited by Douglas F. Miner and John B. Seastone. v.p., diagrams, 15 × 22 cm. New York, John Wiley & Sons, Inc., 1955. Price, $17.50.

Under one cover an engineer can now find information on all the important engineering materials. In this *Handbook* are data on material specifications and standards, statistics on the application of materials, mathematical and physical tables; all kinds of metals and alloys; many kinds of nonmetallic materials such as wood, plastics, paper, ceramics, lubricants; and such construction materials as concrete, roadbed materials, timber and glass. All the information is very orderly, well arranged and carefully indexed. References are appended to each section in case more data are needed.

NIELS BOHR AND THE DEVELOPMENT OF PHYSICS, edited by W. Pauli. 195 pages, diagrams, 15 × 22 cm. New York, McGraw-Hill Book Co., Inc., 1955. Price, $4.50.

On October 7, 1955, that grand old man of physics, Niels Bohr, attained his 70th birthday. Physicists all over the world have taken

this date as a time to honor him and this volume is a colection of articles summarizing the significant developments in physics of the 20th century. So great is the stature of Professor Bohr that in nearly all these developments he played a role either as the initiator of the theory, or as the teacher or father confessor to the new youth of physics who came to the master for guidance, instruction and help.

Niels Bohr and the Development of Physics consists of ten articles on some phase of atomic and nuclear physics written by the foremost authorities in their fields. Men like Pauli, Heisenberg, Friedman and Wheeler have contributed to this book. The subjects covered range from "the discovery of atomic number," "Quantum Theory and relativity" to "Nuclear fission and nuclear stability."

The essays are written in a highly technical manner which effectively excludes them from being read by anyone except an expert in the field.

DRYING AND DEHYDRATION OF FOODS, by Harry W. von Loesecke. Second edition, 300 pages, diagrams, 15 × 22 cm. New York, Reinhold Publishing Corp., 1955. Price, $7.50.

A thorough revision of this classic text, first published in 1943, will prove welcome to food technologists and others concerned with the handling of food products. Complete details for the construction and operation of the most modern types of dehydration equipment are given for all kinds of foods—fruits, vegetables, meats and fish, as well as dairy products. As the only book devoted solely to the dehydration of food products, this up-to-date edition will be of real service.

THE MODERN BUILDING ENCYCLOPEDIA, edited by N. W. Kay. 768 pages, diagrams, 15 × 23 cm. New York, Philosophical Library, 1955. Price, $15.00.

Over thirty specialists have contributed to this comprehensive volume, planned to meet the needs of the building industry, including contractors, students and apprentices. Entries are strictly alphabetical and are not divided into different headings. Entries are cross-referenced to facilitate rapid use, and the book is interspersed with some 800 drawings. The explanations of terms are concise and up-to-date.

ORGANIC SYNTHESES, edited by T. L. Cairns. Vol. 35, 122 pages, 16 × 24 cm. New York, John Wiley & Sons, Inc., 1955. Price, $3.75.

This new volume in the extremely useful series contains 36 entries of new preparations and the usual subject index. The index covers Volumes 30 through 35. The series is so well known that it suffices to note that the new volume has been published.

BASIC MATHEMATICS FOR SCIENCE AND ENGINEERING, by Paul G. Andres, Hugh J. Miser and Haim Reingold. 846 pages, diagrams, 16 × 24 cm. New York, John Wiley & Sons, Inc., 1955. Price, $6.75.

This is a revision of a 1944 publication printed as *Basic Mathematics for Engineers.* The book contains sections on every phase of mathematics from simple algebraic operations through the differential calculus. Examples are given at the ends of each paragraph with the answers in the back of the book to make this work applicable as a text on mathematics.

PUBLICATIONS RECEIVED

INTRODUCTION TO MODERN PHYSICS, by F. K. Richtmyer, E. H. Kennard, and T. Lauritsen. Fifth Edition, 666 pages, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., 1955. Price, $8.50.

THE COMMON SENSE OF THE EXACT SCIENCES, by William Kingdon Clifford. Reissue of original, with redrawn figures, newly edited, with a preface by Bertrand Russell. 249 pages, diagrams, 14 × 21 cm. New York, Dover Publications, 1955. Price: $3.00 (cloth); $1.60 (paper).

MATTER AND LIGHT: THE NEW PHYSICS, by Louis de Broglie. Reprint edition, 300 pages, 14 × 21 cm. New York, Dover Publications, 1955. Price, $1.60 (paper).

TRIGONOMETRICAL SERIES, by Antoni Zygmund. Unabridged and unaltered republication of the 1935 edition. 329 pages, 14 × 21 cm. New York, Dover Publications, 1955. Price, $1.85 (paper).

THE MATHEMATICAL ANALYSIS OF ELECTRICAL & OPTICAL WAVE-MOTION, by H. Bateman. Unabridged and unaltered republication of the first edition, 159 pages, 14 × 21 cm. New York, Dover Publications, 1955. Price, $1.60 (paper).

PARTIAL DIFFERENTIAL EQUATIONS OF MATHEMATICAL PHYSICS, by A. G. Webster. Unaltered and unabridged republication of the second edition, 440 pages, 14 × 21 cm. New York, Dover Publications, 1955. Price, $1.98 (paper).

GAS TURBINES AND JET PROPULSION, by G. Geoffrey Smith. Sixth edition, 412 pages, plates, illustrations, 15 × 22 cm. New York, Philosophical Library, 1955. Price, $15.00.

CROP PROTECTION, by G. J. Rose. 223 pages, plates, 15 × 23 cm. New York, Philosophical Library, 1955. Price, $10.00.

CLASSICS OF BIOLOGY, by August Pi Suñer, translated by Charles M. Stern. 337 pages, 15 × 23 cm. New York, Philosophical Library, 1955. Price, $7.50.

THE VALUE JUDGEMENT, by W. D. Lamont. 335 pages, 15 × 23 cm. New York, Philosophical Library, 1955. Price, $6.00.

DICTIONARIES, BRITISH AND AMERICAN, by J. R. Hulbert. 107 pages, 15 × 22 cm. New York, Philosophical Library, 1955. Price, $2.50.

SENSITOMETRY, by L. Lobel and M. Dubois. 261 pages, diagrams, 13 × 19 cm. London, Focal Press, 1955. Price, 25/.

EXPOSURE, by W. F. Berg. 443 pages, plates, diagrams, 13 × 19 cm. London, The Focal Press, 1955. Price, 21/.

BETTER COLOR MOVIES, by Fred Bond. 159 pages, plates, illustrations, 16 × 24 cm. San Francisco, Camera Craft Publishing Co., 1955. Price, $4.95.

KODACHROME AND EKTACHROME, by Fred Bond. Fourth edition, 252 pages, plates, illustrations, 21 × 28 cm. San Francisco, Camera Craft Publishing Co., 1955. Price, $8.75.

Tough Whiskers now Grown from Many Metals.—Super-strong perfect crystals of a wide variety of metals can be made by the same process General Electric scientists discovered several years ago to make the first perfect crystals of iron. Strengths up to 120 times normal have been observed in the perfect crystals, Dr. C. G. Suits, GE vice president and director of research, announced.

Perfect crystals of gold, silver, platinum, copper, nickel and cobalt have been grown by Sidney S. Brenner in the process, which uses a high concentration of metal in the form of gas, obtained either by chemical means or by boiling the metal. For example, the reduction of any volatile salt of a metal with hydrogen is a suitable chemical means. Earlier this process had produced perfect crystals of iron with tensile strengths of approximately one million pounds per square inch. Achievement of perfect iron crystals was announced by the General Electric Research Laboratory in March 1954.

Dr. Suits also revealed that GE scientists have devised a new method of measuring the crystals' extraordinary strengths. Strength tests of metals are usually conducted on specimens with diameters of the order of one quarter or one half inch. Similar tests on perfect crystals posed difficulties until development of the new technique because the so-called perfect crystal "whiskers" are only about one thousandth of an inch thick.

GE scientists point out that metals are ordinarily from 10 to 1000 times weaker than they theoretically should be, due to imperfections in the crystals which constitute their basic structure. In perfect crystals such imperfections are almost eliminated, and metals achieve strengths approaching those indicated by theory.

Recent GE research on copper has shown that its perfect crystals can withstand tensile stress as high as 600,000 psi. In contrast, samples of ordinary annealed copper, composed of more than one crystal, break at 30,000 psi. and single imperfect crystals break at only 5000 psi.

Another characteristic of the crystal whiskers is their ability to "remember" their original shape. When stressed beyond a certain point, a whisker will remain bent, but if it is then heated it will return to shape. A deformed whisker of copper, for example, when heated 40 min. to over 1000° C. shows this recovery characteristic, as remarkable a performance as if a crumpled automobile fender were to spring back into shape after merely being heated.

The new method of testing crystal strength involves placing a whisker in a vertical position and embedding the upper end in a glass-like substance which has been heated to the melting point. As this substance cools it hardens, firmly gripping the top of the whisker. The bottom of the whisker is similarly attached to a glass cylinder floating in a container of oil. The test is conducted by siphoning oil out of the container, thereby reducing the buoyant force supporting the glass float and causing its weight to apply a downward pull on the whisker. In cases where large loads are applied, a magnet is enclosed in the glass float and the float is pulled downward when cur-

rent is applied to a solenoid which surrounds it. The resulting elongation and eventual breaking of the whisker are projected on a screen for viewing.

The method previously used for testing whisker strength involved measuring the amount a whisker bent under a load applied from one side. With this method the greatest stress was concentrated at one point, rather than being evenly distributed throughout the test sample. The fact that results of the two systems of testing are in close agreement will enable both methods to be used with confidence in the future.

GE scientist Dr. Gerald W. Sears, who several years ago succeeded in growing whiskers of mercury, has since been concerned with formulating a theory which will explain in detail how perfect crystals are produced. The magnetic characteristics of perfect crystals and various techniques for producing them are also under study at the Research Laboratory it was announced.

Mycostatin Available for Laboratories.—Mycostatin (nystatin), an antifungal antibiotic recently introduced for therapeutic use, is now available from E. R. Squibb & Sons, New York, in a form suitable for use in tissue culture and for other laboratory purposes.

The new antibiotic offers for the first time an agent which effectively controls molds and yeasts but is non-toxic to tissue cells and viruses. It has been of value in experimental or vaccine production of many viruses, including those of polio, hoof and mouth disease, influenza, African encephalitides, and herpes simplex.

For laboratory use, the material is supplied as a finely-divided sterile powder which forms a suspension in aqueous media.

Mycostatin has proved effective in preventing mold and yeast contamination of tissue cultures and of various materials prior to their addition to tissue cultures. Its use is also recommended to suppress fungi in procedures for the isolation of virus from stool specimens, throat swabs, and other highly contaminated materials. According to Squibb, no strains of yeast or molds significantly resistant to Mycostatin have been encountered.

At the recommended level of approximately 100 units per milliliter of medium, Mycostatin is fungicidal. No deleterious effects of any kind have been observed on cells in tissue culture with these concentrations of the antibiotic, and some investigators have reported the routine use of higher concentrations without toxic effects. The suggested level can be exceeded several fold without damage to tissue cells.

The material is supplied in vials containing 500,000 units of the antibiotic. Although its activity varies somewhat among batches, one milligram of the powder is equivalent to approximately 2500 units of antibiotic.

Aerial Work Platform to Replace Scaffolding.—The Navy's Bureau of Supplies and Accounts announced that its Oakland Supply Center has developed an aerial work platform that rises vertically 70 feet and will make expensive scaffolding in aircraft hangers a thing of the past. Originally designed for use at the Kaneohe Bay Marine Corps Air Station on Oahu, Hawaii, the work platform sets on a telescoping tube powered by a hydraulic pump. In this way it is similar to an automobile service station hydraulic lift. For Navy use, the platform will be used to provide working space for workmen who must paint hanger ceilings, replace light bulbs, or service fire control sprinklers. Since it can rise so high, it is easily adaptable to almost any con-

struction or repair job in today's mammoth aircraft hangers.

Built to accommodate four workmen, the outsized lift will safely carry a load of 1500 lb. Power is supplied by an electric motor which can be plugged into any standard 220 volt power line or generator. Should the power fail, even with the tower fully extended, the platform can be safely lowered with a manual control.

Another manual control rotates the four by eight platform in a full circle. The tower is mounted on a portable base with bracing legs which can be extended into work position.

Presentation of Approach Speed.—A new carrier approach system which enables the pilot to keep his eyes on the carrier deck and not on his instrument panel is currently being considered by the Bureau of Aeronautics and will be tested at the Naval Air Development Center, Johnsville, Pennsylvania. With the new system the pilot approaching the carrier hears a steady tone in his earphones if his speed is correct. If he is approaching too fast, a high pitch pulsed tone is heard. Contrarily if the pilot's speed is too slow, the tone is low pitched. The rate of pulsation of the tone increases with departure from the desired approach speed.

The system is already in use in British carrier aircraft. Originated by Surgeon Commander Ellis of the Institute of Aviation Medicine, Farnborough, it was developed by him and Mr. A. Burrows of that department to supplement the English built Mirror Landing System. The Mirror Landing System, which replaces the Landing Signal Officer aboard carriers with a concave mirror, requires that the pilot fly his plane to the deck by keeping a reflected image of a reference light centered in the mirror. Doing that the pilot must keep his eyes outside the aircraft and on the mirror, thus the necessity for an aural speed indicator.

Since the U. S. Navy is presently testing the Mirror Landing System and very seriously thinking of adopting it, it is only natural that they should now be investigating the aural presentation.

In addition to the aural speed indication, the Bureau of Aeronautics is working on an idea of cockpit lights equivalent to the aural system.

A system of these lights is now under evaluation at the Naval Air Test Center, Patuxent River, Maryland, in a TV-2 jet trainer. The proposed system consists of three small lights in a vertical scan. When the middle light is on, speed is correct. Top and middle light on, too slow, top light only, much too slow, with the same sequence of the bottom light indicating too fast.

Small-Boat Radio Beacon.—A new compact and inexpensive radio beacon for guiding small fishing vessels into harbor when visibility is bad has been developed by the British Admiralty Signal and Radar Establishment at Portsdown. Known as the microwave harbor beacon, the apparatus consists of a three-centimeter radar-type transmitter mounted at a harbor entrance and radiating from two aerials with overlapping beams. It is an adaptation of the old Lorenz type of landing aid for aircraft. The transmitter is so sited that the line of intersection of the two beams is along a safe course for entering harbor. Trials and demonstrations of the equipment have been carried out at Fraserburgh and Arbroath in Scotland. It is reported to operate very satisfactorily to a range of approximately seven miles from harbor.

Jet Heating of Airports.—Airports of the future may be warmed by the heat generated by vertically rising jet aircraft taking off through tubes from underground terminals. That, at least, is the prediction of Mr. Peter Masefield, Managing Director of Bristol Aircraft Ltd. and former Chief Executive of British European Airways.

Mr. Masefield has suggested that when vertical takeoff and landing are achieved it may become possible to discard "the acres of concrete" which now constitute modern airports. But these vertically rising planes will probably have to fly from the spouts of underground terminals in order to minimize noise. Such a method would combine quietness with central heating for all neighboring buildings as a by-product of the jet efflux.

Gas-Turbine Electric Locomotives.—The Union Pacific Railroad has ordered fifteen 8500-hp. gas turbine-electric locomotives from the General Electric Company and has expressed intent of ordering two additional blocks of fifteen locomotives each. It is believed that these locomotives will be the most powerful internally-powered units ever built.

The new locomotives will be built in two sections (permanently coupled together) with an enginemen's cab at one end. A fuel tender will be coupled behind the locomotive. Geared for freight service, they will have a top speed of 65 miles per hour and will weigh 408 tons on 12 axles. Over-all length with the fuel tender will be 165 ft. 8½ in. and height will be 16 ft. 2 in.

A gas turbine powerplant is similar to that of a jet engine, except there is no jet "thrust" for propulsion as in a plane. In a locomotive the turbine is connected through reduction gears to electric generators which supply power to the driving motors on the axles.

Gas turbine-electric locomotives pack a large amount of power into a comparatively small space, require no water, have fewer moving parts than other types of similar horsepower and use a low cost treated bunker C oil as fuel.

The fuel tenders for the locomotives are being built by Union Pacific. They are used in order to keep the weight of the locomotive on the driving wheel constant instead of losing weight and traction as the fuel is burned.

The fuel tenders will be 46 ft. 5½ in. long and will have a capacity of 24,000 gal. They will be insulated with 4 in. of glass wool in order to retain the heat of the fuel which is heated as it is placed aboard.

Portable Psychrometer.—G. M. Manufacturing Co. (New York) announces its Gemware Portable Psychrometer, motarized, battery operated, for use in accurately obtaining relative humidity measurements in connection with meteorological studies, air conditioning research, commercial manufacturing, cold storage systems, and public buildings. Industrial plants engaged in the fields of plastics, chemicals, films, tobacco, alcohol, furs, textiles, printing, etc. will find it a useful device for obtaining necessary technical data for processing, storage and other processes where humidity has a bearing.

The instrument functions like the standard Weather Bureau sling psychrometer, except that the air is sucked past the thermometer bulbs, instead of whirling the instrument in the air. It is designed to obtain accurate measurements. It consists of a housing with an air intake tube connected to a special duct system with exhaust slots, a high speed precision 4½ V. motor with Nylon fan blade, three standard flashlight batteries for power supply, a pair of carefully matched and accurately

calibrated thermometers, a water reservoir and wick connected to the wet bulb thermometer, and an On-Off switch.

The Gemware motorized psychrometer has been designed for field use; it is ruggedly constructed. The thermometers are shock mounted with spring clips and rubber grommets. The top cover plate and the side plate are easily removed. The water reservoir eliminates the need for wetting the thermometer wick before each test and avoids the necessity of carrying a container of water around since the reservoir contains enough water for about a week's use when operated intermittently, daily. With the motor and fan On, the thermometers will stabilize in about 20–30 seconds. This quick reading is obtained because the wick is always wet and partial evaporation, even when not in operation, causes the wet bulb thermometer to read slightly lower than the air thermometer. The motor has oil impregnated bearings and is insulated from the thermometer bulbs and air duct system. The moving air is exhausted through vents at the sides of the housing.

The thermometers have a magnifying front which shows the mercury up as a heavy line. A special type of glass is used to reflect the mercury red, instead of silvery, making it very easy to read. The standard range is 20 to 120° F. in 1°, accurate to within 1° at all points. They are selected and matched in pairs for best results. Centigrade thermometers 0–50° C. in 0.5° can be furnished at no extra charge. Special range thermometers, to order.

The Gemware Psychrometer is small and light-weight, measuring 7½ in. × 3¼ in. × 1½ in., and weighs 1½ lb. with batteries. Because of its design and size it can be used for measurements in small ducts, display cabinets, tobacco cases, or other places where sling psychrometers cannot be used.

Fire Retardant Paints.—Fire retardant paints which slow down the rate of burning have been developed by the Corps of Engineers' Research and Development Laboratories, Fort Belvoir, Va. Containing certain pigments and oils which form a spongy insulating layer when subjected to heat, they feature all the esthetic and protective properties of good interior and exterior paints, according to Mr. Harvey Miller, a project engineer in the Laboratories' Materials Branch.

A number of promising pigments and vehicles were investigated before protective coating specialists at the Laboratories were able to come up with these effective fire control aids. Laboratory paints were formulated and tested under various conditions, along with samples submitted by industry.

Since the Army's needs are global, the paints were evaluated in the Arctic, desert, tropics and at Fort Belvoir. Following six-month and one year exposures, they were returned to the Laboratory and evaluated for residual fire retardancy. This was done by burning the test panels in a cabinet under controlled conditions and calculating the amount of weight loss and char volume.

The use of fire retardant paints does not stop fires, but it does aid materially in minimizing damage and loss of life. These paints could have lessened the damage at Hiroshima and Nagasaki considerably. They could become a major aid in our civil defense programs.

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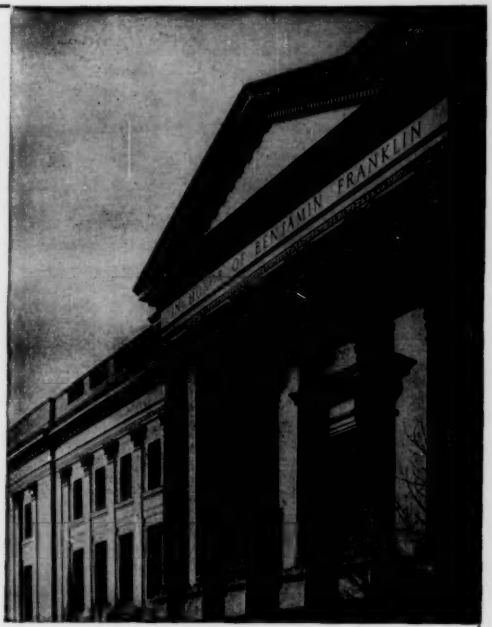

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